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INSTRUCTIONS FOR MAKING BARK BEETLE SURVEYS IN THE VIRGIN PONDEROSA PINE STANDS OF OREGON AND WASHINGTON

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Bureau of Entomology

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INSTRUCTIONS FOR MAKING BARK BEETLE SURVEYS IN THE VIRGIN PONDEROSA PINE STANDS OF OREGON AND WASHINGTON

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I. INTRODUCTION

Annual bark beetle surveys in the ponderosa pine stands of Oregon and Washington were first started on a continuing basis in Southern Oregon in 1921, and later in Washington during 1930. These detection surveys, which have been conducted annually ever since their inception, form the basis for control action and provide mortality data fundamental to forest management plans.

The purpose of these pine beetle surveys has been fourfold: (1) To determine the yearly trend, intensity, and distribution of infestation by the western pine beetle (Dendroctonus brevicomis Lec.) and other insects associated with it in the killing of ponderosa pine; (2) to ascertain the need for artificial control work; (3) to determine the types of trees and the areas which are most susceptible to beetle ravages and which warrant first consideration in timber management plans; (4) to obtain pertinent data to be used in research phases of forest insect investigations.

Due to the seasonal character of the survey there has been a frequent turnover in field personnel. In order to facilitate training of the men and improve the quality of work, it has been necessary to standardize and record the methods used. For this purpose a series of field manuals have been issued, of which this is the sixth since 1938. The methods herein described have been developed through a process of trial and error over a long period of years by the Bureau of Entomology and Plant Quarantine and the U. S, Forest Service.

Types of Surveys

Annual bark beetle surveys are conducted by both extensive and intensive methods.

The extensive phase of the survey consists variously of general observations, topographic reconnaissance, and strip counts. Information thus obtained is of a general nature, and is valuable largely in interpreting intensive plot records in terms of losses for large areas. Experienced personnel conduct the extensive part of the survey by methods not described in this manual.

The intensive phase of the survey consists of a 100 percent cruise of all losses occurring on permanent 320- or 640-acre sample plots scattered throughout representative portions of the ponderosa pine forests of both eastern Oregon and eastern Washington. The 320-acre plot is now standard size; while sufficiently large to give good representation, work on it can easily be completed in one day.

The high degree of accuracy obtained by the sample plot method enables the use of the data for comparative purposes. The data also form the basis for estimating the amount of infestation on surrounding areas when carrying out the extensive phase of the survey. The intensive phase of the survey is carried out in both cutover and virgin stands; however, only the methods used in the virgin stands will be considered in the discussion that follows.

Data Obtained

The data obtained from insect surveys ordinarily comprise information on:

(1) The number, size, and class of trees killed on a given area or plot and the insect or other agency responsible for this mortality.

(2) The distribution of loss by insect responsible, generation involved, or other agency, such as windfall, lightning, or fire.

(3) A map of the area or plot showing distribution of killed trees, grouping, and intensity of loss.

(4) Growth rate of insect-killed and green trees.

(5) An inventory cruise of the green stand is frequently made so as to relate losses to percent of stand killed and to proportion of various tree classes involved.

Survey Personnel

Crew organization.--The three man crew consisting of a crew leader and two assistants has been found to be most efficient on these surveys. This provides a compassman[1] and two spotters[2] for spotting[3] insect-killed trees or for making a 10 percent inventory cruise of the green stand[4] by the random 1/4-acre circular plot method.[5] It also provides a compassman, a cruiser, and an estimator for making a 10 percent inventory cruise by the strip method.[6] The spotters must possess keen eyesight, good color perception, and a certain knowledge of forest insects, especially those of the bark beetle group, including their habits, life history, and character of work. The crew operates under the supervision of a representative of the Bureau of Entomology and Plant Quarantine or the Forest Service. The crew supervisor also carries on the extensive phase of the survey.

1/ Compassman's duties, p. 12.
2/ Spotter's duties, p. 6.
3/ Spotting procedure, p. 6.
4/ Timber inventory cruising procedure, p. 17.
5/ Duties of crew members cruising by the random 1/4-acre circular plot method, p. 19.
6/ Duties of crew members cruising by the strip method, p. 18.

II. PLOT PROCEDURE - GENERAL

New Plots

The locations of proposed check plots are tentatively selected in the Portland office by using available type maps, cruise figures, site data, etc. These selections are then checked in the field by the crew supervisor. If found unsatisfactory, the location is changed to some nearby section. Once a plot has been chosen, the crew members proceed as follows:

(1) Establish control lines. (See discussion below)
(2) Spot insect-caused losses. 1/
(3) Take tree height measurements to determine site 2/
(4) Take increment cores to determine growth rate. 3/
(5) Take a ten percent inventory cruise. 4/
(6) Prepare plot description on standard form. 5/
(7) Prepare envelope for filing plot data. 6/

Procedure of Establishing Plots

Two control lines are established, one at each end of plot. Each line is 40 chains in length and extends across the lateral axis of plot; that is, from section corner to quarter corner.

Control line No. 1 - With a staff compass 7/ carefully retrace the original G. L. O. survey line from identified section corner of plot to quarter corner. Measure distance with 2 1/2 chain topographic tape 8/ and abney level. 9/ Brush out well and blaze. Erect tally markers at five chain intervals along line. Number markers consecutively from 1 to 7, Marker No. 1 to be five chains from section corner. Upon completing line No. 1, return to Tally Marker No. 1. Starting at this point a regular strip 80 chains in length is spotted through plot to opposite section line. Upon arriving at section line, locate section corner and establish control line No. 2 the crew start at Tally Marker No. 7 and spot the remainder of the plot in the usual manner.

1/ Spotting procedure, p. 6.
2/ Measuring tree heights, p. 22.
3/ Increment cores, p. 21.
4/ Timber inventory cruises, p. 17.
5/ Preparation of plot description, p. 4.
6/ Preparation of plot envelope, p. 5.
7/ Compass, p. 27.
8/ Topographic trailer tape, p. 29.
9/ Topographic abney level, p. 29.

Tally markers are to be constructed in the following manner. Build rock monument at least 16 inches in height. Make 4x6 inch blazes facing monument on two trees standing one on each side of monument and not over 16 feet distant. With keel write number of tally marker on blazes. Place symbol "T" for tally directly above marker number. If trees are not present use a three or four inch stake about 4 1/2 feet long. Drive into ground and build monument around it. Smooth up two opposite sides and place numbers on stake. If rocks are not available use stake and trees to mark location.

Duties of Crew Members in Establishing Control Lines

Compassman:

Runs compass,[1] acts as head chainman, and assists in building of monuments for tally markers.

Spotter No. 1:

Acts as rear chainman, carries abney level,[2] and makes slope corrections;[2] assists in brushing out and blazing line and building of tally monuments.

Spotter No. 2:

Brushes out and blazes lines; secures and prepares tally stakes; assists in building tally monuments; places tally numbers on stakes or trees.

Preparation of Plot Description

One Plot and Physical Description form is to be completed during the course of establishing each plot. This form is self explanatory. Sketch in the roads, section corners found, starting point, etc. A completed sample is shown on page 35. Also at the time of plot establishment, concise instructions as to the location and accessibility of each plot are to be entered on the Guide to Plot form, see page 34. Exercise utmost care in writing up instructions on how to reach the plot as future crews will rely upon this information.

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[1] Compass, p. 27.
[2] Abney level and topographic tape, p. 29.

Preparation of Plot Envelope

A 9 1/2 x 11 3/4 manila envelope is provided for each new plot. On the face and near the top of each envelope, print in large letters with ink the following headings:

CHECK PLOT DATA

Forest_____
Area_____
Unit_____
Plot Name_____
T._____ R._____ Sec._____

For each plot, fill in the information indicated above. All plot data are filed in their respective envelopes which are kept in the office box during the survey period.

Guide to Plot cards with instructions as how to reach individual plots are permanently filed in the plot envelopes for use on future surveys.

Old Plots

The location of established plots is shown on forest maps provided the survey crews. Detailed instructions on how to reach the plots are given on the Guide to Plot form[1] filed in the plot envelopes, see above. These instructions should be kept current by noting any changes in roads or other features that affect access to plots.

Once a plot is reached and the starting point located, the spotting[2] of insect-killed trees is done in the usual manner. Losses[3] to be marked consist of those that have developed since the last survey. In order to maintain the plots in workable condition, it is necessary to replace all missing tally markers,[4] renumber markers that have become illegible, and keep control lines brushed out.

1/ Guide to plot, p. 34.
2/ Spotting procedure, p. 6.
3/ Seasonal identification of loss, p. 10.
4/ Establishing control line, p. 3.

III. SPOTTING

The term "spotting" as used in bark beetle surveys, means the locating, marking, and recording of trees that are, or have been, infested with insects. A crew composed of two "spotters" and a compassman does the 'spotting".

Procedure

Using a staff compass [1] and by pacing [2] the compassman [3] maintains a true line and correct measure of distance through each plot. He maps [4] topography and the locations of all trees marked by the spotters, see below. Each spotter covers a five chain strip on which he locates, marks, and records [5] all trees above 9.6 inches D.B.H. that have died since the last survey. [6] One spotter ranges to the right, the other to the left of the compassman.

From the starting point, usually tally marker No. 1, the crew moves through the plot. Upon arrival at the like marker on the opposite control line the crew offsets 10 chains to tally marker No. 3 and returns to marker No. 3 on the starting line. The next two lines are run in a like manner from tally markers 5 and 7 respectively, thereby completing coverage of the entire plot. Upon completion of the field work the plot data are summarized [7] and then filed in the plot envelope. [8]

Spotter's Duties

The spotters are responsible for the detection "spotting" of all trees killed since the previous survey. The spotter detects the trees by noting certain external indications: namely, sickly, fading, or faded foliage; fresh or recent pitch tubes; sawdust in bark crevices; insect emergence holes; and woodpecker work, either scaling or individual holes in the bark on the bole. When one or any combination of the above indications are present, chopping through the bark usually reveals the insect broods or indications of their having been present. On green trees where external and internal indications of the presence of insects or attack are vague, care should be exercised not to injure the tree unduly in making examinations.

1/ Compass, p. 27.
2/ Pacing, p. 13.
3/ Compassman's duties, p. 12.
4/ Mapping, p. 15.
5/ Recording spotting data, p. 8.
6/ Seasonal identification of loss, p. 10.
7/ Summary of spotting data, p. 9.
8/ Preparation of plot envelope, p. 5.

Having determined that a tree requires marking, the spotter calls "Bugs" to the compassman who answers and halts his line. The spotter then makes a smooth, 4 x 8 inch blaze on the wood at eye level on the north side of the tree. While approaching the tree and during the course of examination and blazing he determines the year of the tree's death[1] and the agency[2] responsible. Using a black or blue keel, he prints on the blaze the last two digits of the year in which the tree was killed. Under these he draws a line below which he enters the serial number of the tree. (Prior to 1942 the beetle brood was indicated by an "S" or "W" placed beneath the year. "S" indicated a summer brood and "W" an overwintering brood.) On each plot the serial numbers for the current season's loss start at 1, and for the past season's loss at 501. One spotter uses the numbers 1 and 501, the other 101 and 601. The following is an example of marking on the 1942 survey:

Current Years Loss		Past Years Loss	
42 / 1	42 / 101	41 / 501	41 / 601

After numbering a tree the spotter measures its diameter with a Biltmore stick[3] or diameter tape[4] determining its classification,[5] [6] records these data[7] on the proper spotting record,[8] and calls in the serial number to the compassman who repeats the number to verify it. Only the first and last serial numbers of trees in a group are called in. All marking and recording operations on both single trees and groups must be completed before calling in serial numbers. Upon receiving a number, the compassman maps[9] the location and then the entire crew moves forward again. Spotters should cooperate in marking large groups. Windthrown trees of the current year are blazed on the top side 4 1/2 feet from the stump and are marked in the same manner as standing trees. The data, however, are recorded on a separate spotting record.

The spotters should pace[10] out the width of their strip "5 chains or 330 feet" until they can estimate it reasonably well. Covering too wide or too narrow a strip results in either holding up the crew or missing trees. Care must be exercised near the ends and sides of a plot in order not to mark any trees outside of the boundaries. Spotters must respond to the compassman's tally calls to enable the crew to move in unison.

1/ Seasonal identification of loss, p. 10.
2/ Agencies responsible for death of trees, p. 9.
3/ Biltmore or forest cruiser stick, p. 24.
4/ Diameter tape, p. 27.
5/ Keen tree classification, p. 44.
6/ California risk rating classification, p. 55.
7/ Recording of spotting data, p. 8.
8/ Spotting record, p. 37.
9/ Mapping, p. 15.
10/ Pacing, p. 13.

After the field work is completed the spotters enter the volumes of all trees on spotting records, see below. They also summarize the spotting data and file it in the proper manner.[1]

Spotting axes must be kept sharp to insure a smooth blaze on which to write legibly. Equipment used by each spotter is listed on page 30.

Recording of Spotting Data

The method of recording spotting data is shown on a sample spotting record on page 37. Each spotter uses three sets of these records: One for the past year's loss,[2] one for the current year's loss,[2] and one for the current year's windthrown trees.

Fill out headings on each record. Place name of forest above "Project Area". On line following "Project Area" enter area name, and enter unit name following "Unit". Cross out "Camp No.", substitute "Plot," and enter plot name. On the next line and in the spaces provided, enter date, spotter's name, and plot location.

Above "Tree No." in column one, write in year of loss.[3] Under "Tree No." enter serial numbers of trees marked. Serial numbers of trees in a group are to be enclosed with a bracket placed in front of the numbers. Under "Killed By" enter symbol of agency responsible for death of tree.[4] Under "D.B.H." enter diameter of tree at breast height. The column under "Logs" remains blank except in unusual cases when tree heights are recorded in number of 16-foot logs. No entries are made in the "Volume" column until completion of the field work on a plot. Then enter the board foot volume of each recorded tree by referring to the appropriate volume table.[5] The next two columns remain blank. At the top of the eighth column write in "Tree Class". In this column enter the tree classification.[6][7] Under "Remarks" enter any pertinent information as to condition of brood or tree.

Windthrown trees are entered on separate spotting records labeled "Windthrow" in the upper right hand corner. Both windthrown and beetle-killed trees are numbered consecutively in the same series according to year of mortality. The same data are recorded for both types of trees.

1/ Summary of spotting data, p. 9.
2/ Seasonal identification of loss, p. 10.
3/ Spotter's duties, p. 6.
4/ Agency responsible for death of tree, p. 9.
5/ Adjusted volume tables, p. 59.
6/ Keen tree classification, p. 44.
7/ California risk classification, p. 55.

Summary of Spotting Data

All spotting data are summarized separately by year of loss, either past or current. Total trees and volumes on each spotting record and place totals at bottom of sheet. See sample record on page 37. Next sum up totals for year and enter under "Remarks" on map of that year as shown on sample map on page 36. Do not include windthrow with insect-caused loss. To lessen the danger of lost data, file as soon as summarized. Place each year's records together with map on top and fasten with "Gem" clip, then place in plot envelope and file in office box. Uncompleted data must not be allowed to accumulate.

Agencies Responsible for Death of Trees

While there are a great number of agencies which may cause the death of ponderosa pine, only ten of the most important ones have been selected for recording.[1] These are listed below in the order of their importance, together with the abbreviations used in recording.

Dendroctonus brevicomis Lec. --- D. B.

The most important and common bark beetle that attacks trees above six inches in diameter.

Melanophila californica Van Dyke. --- F. H.

Prefers trees on hot, dry sites, frequently causing top killing.

Dendroctonus monticolae Hopk. --- D. M.

Generally found on north side of tree or in cool, moist sites.

Ips oregoni Eich. --- I. O.

Attacks reproduction and smaller trees or tops of larger trees.

Ips emarginatus Lec. --- I. E.

Attacks all sizes of trees, generally found in conjunction with D. M.

Dendroctonus valens Lec. --- D. V.

Attacks the bases of trees. Its attacks frequently precede those of other insects.

Fire. --- F.

Trees must have all needles scorched.

Lightning. --- L.

Tree must be shattered. One stroke down a side is insufficient to cause death.

---

[1] Recording of spotting data, p. 8.

Wind Throw. --- W. T.

All windthrown trees are recorded on a separate spotting record labeled "Windthrow" in upper right hand corner.

Unknown. --- U.

To be used when cause of death of tree cannot be ascertained. Other important agencies contributing to the death of a tree to be entered under "Remarks".

For further reference on the insects each crew will be provided with one copy of USDA Miscellaneous Publication No. 273, "Insect Enemies of Western Forests".

Seasonal Identification of Loss

The identification of beetle-killed trees as to time of attack is a difficult phase of the spotter's work. As the surveys are usually conducted during the season of beetle activity, attacks continue after the plots have been spotted, resulting in a portion of each year's loss remaining unmarked until the survey of the following year. This necessitates marking portions of two years' losses on each annual survey, and requires two annual surveys to complete the loss data for one year. For comparative purposes these losses are recorded according to year of death of the trees rather than by year in which the trees are marked.

While attacks occur with greater intensity at certain periods, some occur throughout the season, resulting in considerable variation in brood stages and tree condition at all times. Further variations are caused by species of insect attacking, exposure, elevation, latitude, type of soil, and weather conditions. As a result of these variations none of the characters used in determining time of attack have proven infallible once the brood emerges.

Although seasonal differentiation is no longer recorded, the following characters developed for that purpose may prove helpful in identification of D.b. trees of the current and preceding years during the months of August, September, and October when the annual surveys are normally made.

(1) Loss of Previous Year

(a) Summer brood. Attacks occur early in spring to late in summer.

Foliage. Dark red. Many of long needles fallen. Short needles still on ends of twigs.

Bark. Usually dry and loose, with loose boring dust under bark. Pitch tubes hard and yellow. Many D.b. emergence holes. A number of large oval holes. No fresh woodpecker work. Old work, may consist of light to moderate scaling considerably weathered. Also many small round woodpecker holes through bark. Frequently many hard, dry fungus fruiting bodies, considerable portion of which have broken open or fallen.

Wood. Usually dry and checked. Much bluestain. Occasionally punky. Frequently many worm holes in sapwood.

Insects. Only a few secondary insects.

(b) Winter brood. Attacks occur late in summer until cold weather.

Foliage. Sorrel to red. Needles normal length. Some fallen.

Bark. Usually loose. Boring dust generally loose. White dust common in crevices. Pitch tubes becoming hard and yellow. Many D.b. emergence holes in bark. Some large, oval holes. Heavy woodpecker work frequent. None recent. Fungus fruiting bodies dry and hard, few in number.

Wood. Mostly dry, occasionally moist. Much bluestain. A few small worm holes.

Insects. No D.b. Many secondaries. An occasional roundheaded borer larva.

(2) Loss of Current Year

(a) Summer brood. Attacks occur from early spring to late summer.

Foliage. Green fading to sorrel. No loss of needles. New growth short on ends of twigs.

Bark. Fairly loose and moist. Red and occasionally white boring dust in crevices. Pitch tubes red and becoming hard. May or may not be numbers of D.b. emergence holes. No large oval holes. Woodpecker work light to moderate. Frequently only small round holes through bark. Fungus fruiting bodies may be infrequent.

Wood. Moist with considerable bluestain. May be a few small worm holes.

Insects. On trees attacked early in season emergence of D.b. brood complete, later trees may have larvae, pupae, and new adults. Many secondary insects both in adult and larval forms. Roundhead borers may range from small to full-grown larvae.

(b) Winter brood. Attacks occur in late summer and until cold weather.

Foliage. Fresh green to straw yellow. Fully developed needles.

Bark. Moist and generally tight. Red dust in crevices. Pitch tubes soft and red. Insect holes few. No large oval holes. Woodpecker work becoming prevalent. No fungus fruiting bodies.

Wood. Moist, unstained to slightly bluestained. No worm holes.

Insects. D.b. new attacks, parent adults, eggs or larvae. On advanced trees may be a few small to half grown roundheaded borer larvae. May be clerid adults on bark. Few secondary insects under bark.

IV. MAPPING

Compassman's Duties

(1) The compassman is responsible for directional and distance guidance of the crew. He locates section corner of plot and starting point on control line,[1] which usually is tally marker No. 1 five chains from section corner. Using a staff compass which he corrects for magnetic declination[2] to that given on Guide to Plot form,[3] and by pacing[4] to measure distance, he runs four lines, each 80 chains in length, at 10-chain intervals parallel to the longitudinal axis of each 320-acre plot. He must inform the spotters when starting through and completing the strip. He calls out every tally[4] on the strip as this is the only means the crew has of keeping together in rough or brushy country. He should never be more than a tally ahead or behind the spotters.

1/ Procedure of establishing plots, p. 3.
2/ Compass, p. 27.
3/ Guide to plot, p. 34.
4/ Pacing, p. 13.

(2) When a spotter calls, "Bugs" which indicates that he has found a tree requiring marking, the compassman responds to the call and halts his line until receiving the serial number[1] of the tree. The spotter does not call this number until marking is completed. The compassman repeats number to spotter for verification, plots the number on the proper map[2] for the year of loss and proceeds with the line.

The tree number indicates the year of loss. All serial numbers above 500 are the past season's loss; all serial numbers under 500 are the current season's loss.

On the current season's loss map the compassman also maps all physical and cultural features using standard map symbols.[3]

(3) Upon completion of field work on plot, in cooperation with spotters, he places summary of each year's loss on proper maps.[4]

Equipment used by compassman in field is listed on page 31.

Pacing

Pacing is measuring distance in terms of regular steps or strides. The military pace is the length of step in walking, usually measured from the heel of one foot to the heel of the other foot, ordinarily 2.5 feet.

The pace referred to and used by woodsmen is a stride or Roman pace, the distance covered in walking from the heel of one foot to the heel of the same foot, approximately 5 feet. The present measurement of a mile originated from the 1000 paces used as a measurement of distance covered by the marching Roman legions.

In pacing take a natural gait. Do not try to fit your pace to a specified distance, rather find out the distance your natural pace will cover. Among individuals, paces per mile will vary from 880 to 1060 or more.

The General Land Office surveys established horizontal measurements. Therefore, when hills are encountered the distance travelled is actually greater than the surveyed distance. This increase of distance must be compensated for. Compensation must also be made for the shorter pace taken when ascending or descending hills, or when encountering brush and other obstructions. This is done by skipping a count every few paces or as often as necessary. Considerable practice is required before a satisfactory ratio can be established for various grades.

1/ Spotter's duties, p. 6.
2/ Mapping, p. 15.
3/ Map symbols for use on survey, p. 16.
4/ Summary of spotting data, p. 9.

The following table may be useful as a guide..

Percent of slope	Ascending		Descending	
	Step	Skip	Step	Skip
60	1	1	3	2
30	3	1	7	2
20	5	1	10	1
10	7	1		

Care must also be exercised to prevent overpacing when going down a gradual slope.

In pacing, the distance of 5 chains is commonly referred to as one tally. There are 16 tallies per mile. A pacing table should be built up to show the number of paces required for each consecutive-tally from 1 to 16. With the aid of this table the pacer's position in the mile can quickly be determined on a map.

Following are pacing tables for 54 to 63 paces per tally.

Tally No.	No. of paces									
1	54	55	56	57	58	59	60	61	62	63
2	108	110	112	114	116	118	120	122	124	126
3	162	165	168	171	174	177	180	183	186	189
4	216	220	224	228	232	236	240	244	248	252
5	270	275	280	285	290	295	300	305	310	315
6	324	330	336	342	348	354	360	366	372	378
7	378	385	392	399	406	413	420	427	434	441
8	432	440	448	456	469	472	480	488	496	504
9	486	495	504	513	522	531	540	549	558	567
10	540	550	560	570	580	590	600	610	620	630
11	594	605	616	627	638	649	660	671	682	693
12	648	660	672	684	696	708	720	732	744	756
13	702	715	728	741	754	767	780	793	806	819
14	756	770	784	798	812	826	840	854	868	882
15	810	825	840	855	870	885	900	915	930	945
16	864	880	896	912	928	944	960	976	992	1008

Many methods may be employed to keep track of the number of paces taken per mile. The simplest and by far the most accurate is to record each pace on a tally register.[1] This operation soon becomes almost automatic, leaving the mind free for other things.

Mapping

The type of map used on check plots, the methods of plotting insect-killed trees marked by spotters, and mapping of topographic and cultural features are shown on the sample "Section Plat" on page 36. Two section plats are required per plot, one for past season's loss and the other for current season's loss. Mapping of physical features is confined to current loss plat.

(1) Plotting of trees

The number within the circle, as shown on the sample Section Plat, represents the number of trees within a group. Numbers immediately above or below the circle represent the first and last serial numbers[2] of the trees within the group. All numbers used in plotting must have tops toward north.

(2) Map legend

Forest Service map symbols with a few additions are used to show physical and cultural features. See Map Symbols for use on Forest Insect Surveys on page 16. Openings or changes in timber type of 5 chains or more in width are to be mapped.

(3) Year of loss

The year of loss each map represents must be clearly shown under "Remarks" on the Section Plat. Serial numbers 1 to 500 represent current season's loss. Those over 500 represent past season's loss.

(4) Plot loss summary

A summary of each year's loss by number of trees and volume is to be shown under "Remarks". See sample Section Plat on page 36.

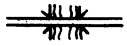
1/ Tally register, p. 29.
2/ Spotter's duties, p. 6.

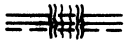
MAP SYMBOLS FOR USE ON FOREST INSECT SURVEY

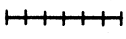
PRIMARY ROADS

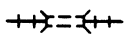
SECONDARY ROADS

TRAILS

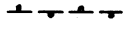

BRIDGES

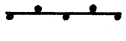

FORDS

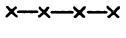

RAILROAD

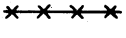

RAILROAD TUNNEL

TELEPHONE LINE ALONG ROAD


TELEPHONE LINE ALONG TRAIL

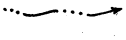

TELEPHONE LINE

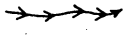

FENCE


FENCE ALONG LAND LINES

RIVER

SMALL STREAM


INTERMITTENT STREAM


FLUME

CANAL OR DITCH

POND OR LAKE

RESERVOIR AND DAM

SPRING

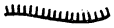
SPRING WITH TROUGH

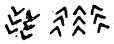
WELL

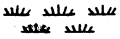
PEAK

RIDGE

CLIFFS


RIMROCK


ROCK OUTCROPPINGS


MARSH OR GRASSLAND

TIMBER TYPE BOUNDARIES

CORNER POSITIVELY IDENTIFIED

CORNER FOUND, NOT POSITIVELY IDENTIFIED

CORNER SEARCHED FOR BUT NOT FOUND

MINE OR QUARRY

CORRAL

SALT TROUGH

SAWMILL

FOREST CAMP

LEANTO

RANGER STATION

SCHOOLHOUSE

HOUSE

SMALL TOWN

BENCH MARK WITH ELEVATION

TRIANGULATION STATION

V. TIMBER INVENTORY CRUISES

A ten percent inventory cruise of the ponderosa pine stand is made on all check plots when established and at certain intervals thereafter. Two methods of cruising have been employed: (1) "The Strip Method" and (2) "The Random 1/4-Acre Circular Plot Method".

The strip method consists of running four strips, each one chain "66 ft." in width and 80 chains in length at ten chain intervals through each 320-acre plot. This type of cruise is carried on by a three man crew consisting of a compassman, cruiser, and estimator.

The random 1/4-acre circular plot method as used on the insect surveys is carried on by the spotting crew in conjunction with the regular spotting procedure.[1] Each spotter while cruising for insect losses on his strip establishes at random one 1/4-acre plot each tally or 16 plots per mile. Sixty four 1/4-acre plots are established by each spotter on a 320-acre check plot.

Procedure

With a Biltmore stick[2] or diameter tape,[3] measure the D.B.H. of all ponderosa pine above 9.6 inches in diameter, both green trees and free standing snags, whose centers are within the boundaries of the one-chain strip, or 1/4-acre plot. Trees forking above breast height (4 1/2 ft. above ground) to be considered as one tree, those forking below this point to be measured as two trees. Classify green trees according to the designated system of tree classification[4] [5] and record on "Tree Class Tally" form by D.B.H. and class. Snags are to be recorded by diameter only.[6]

Current seasons beetle loss[7] to be considered as green trees; previous seasons losses[7] to be designated as snags. Plots to be cruised by the strip method should first be spotted[8] to identify year of loss.

A sufficient number of tree heights are to be taken with an abney level[9] to determine site[10] on the check plot.

Increment cores[11] are to be secured from 15 Class 3A trees[4] during the spotting process.

1/ Spotter's duties, p. 6.
2/ Biltmore stick, p. 24.
3/ Diameter tape, p. 27.
4/ Keen tree classification, p. 44.
5/ California risk classification, p. 55.
6/ Recording of cruising data, p. 20.
7/ Seasonal identification of loss, p. 10.
8/ Spotting procedure, p. 6.
9/ Measuring tree heights, p. 22.
10/ Site and volume table determination, p. 23.
11/ Increment cores, p. 21.

Duties of Crew Members Cruising by Strip Method

Compassman

The compassman runs the compass line[1] and measures distance by pacing[2]; informs estimator when reaching end of each quarter section; drags 2 1/2-chain steel tape which is used in taking tree heights[3] and serves as a base from which the cruiser may gauge his distance; and takes height and diameter[4] measurements of representative trees along compass line in order to determine site[5] on plot. Upon completion of field work the compassman summarizes tree heights[6] and determines site on plot.

Cruiser

With a Biltmore stick[7] or diameter tape[4] the cruiser measures the D.B.H. of all ponderosa pine, both green trees and free standing snags, whose centers are within 33 feet on either side of the compass line; calls the diameter to estimator; remains at tree until estimator repeats its diameter; and holds the rear end of chain to enable compassman to obtain correct distance for measuring tree heights. After completion of the field work on a plot, the cruiser assists the estimator to summarize cruising data.[8]

Estimator

The estimator repeats the D.B.H. measurements called by the cruiser and determines the classification[9] [10] of green trees; enters green tree data and snag measurements in proper place on "Tree Class Tally" sheet;[11] changes sheets at the end of each quarter section. Upon completion of the field work on a plot the estimator, with assistance of the cruiser, summarizes cruising data.[8]

Equipment

Equipment used by crew in field is listed on page 31.

1/ Compass, p. 27.
2/ Pacing, p. 13.
3/ Measuring tree heights, p. 22.
4/ Diameter tape, p. 27.
5/ Site and volume table determination, p. 23.
6/ Summary of height measurements, p. 23.
7/ Biltmore stick, p. 24.
8/ Summary of cruising data, p. 20.
9/ Keen tree classification, p. 44.
10/ California risk classification, p. 55.
11/ Recording of cruising data, p. 20.

Duties of Crew Members Cruising by the Random 1/4-Acre Circular Plot Method

Compassman

In addition to the compassman's duties in the regular spotting procedure[1], he halts the compass line at each tally until both spotters signify completion of the 1/4-acre plots at this point; advises spotters to change tally sheets at end of each 1/2 mile; and secures height and diameter measurements[2] of representative trees along compass line. Upon completion of field work, he summarizes tree heights,[3] plots height curve,[4] and determines site on plot.[5]

Spotters

In addition to the regular spotting procedure[1] each spotter stops wherever he may be on his strip, when each tally[6] is called by the compassman, and proceeds to establish a 1/4-acre circular plot. Each spotter establishes sixteen 1/4-acre plots per mile and 64 per 320-acre plot. To mark the center of the plot the spotter sticks his axe in a tree if one is within reach; otherwise he places it upright on the ground. Using a Biltmore stick[7] or diameter tape[8] he measures all ponderosa pine, green and free standing snags above 9.6 inches D.B.H., standing within a radius of 58.9 feet. He carefully paces[6] the distance to determine the location of trees near periphery of plot. He determines the classification of green trees by the designated system.[9][10] The data are recorded on "Tree Class Tally" sheets.[11] Upon completion of the 1/4-acre plot the spotter calls "Ready" to the compassman and the crew moves forward. Each spotter secures increment cores[12] from at least eight class 3A trees[9] well distributed over the check plot. Upon completion of field work on a check plot, the spotters summarize the cruising data.[13] They also wrap and label the increment cores properly.[12]

Equipment Used

Equipment used by a crew in making random 1/4-acre circular plot cruises is listed on page 30.

1/ Spotting procedure, p. 6.
2/ Measuring tree heights, p. 22.
3/ Summary of height measurement, p. 23.
4/ Height curve construction, p. 23.
5/ Site and volume determination, p. 23.
6/ Pacing, p. 13.
7/ Biltmore stick, p. 24.
8/ Diameter tape, p. 27.
9/ Keen tree classification, p.44.
10/ California risk classification, p. 55.
11/ Recording of cruising data, p. 20.
12/ Increment cores, p. 21.
13/ Summary of cruising data, p. 20.

Recording of Cruising Data

Cruising data are to be recorded on "Tree Class Tally" form (see sample on page 38). Two of these forms, one for each quarter section, are required per 320-acre plot. Fill in all information asked for on form heading. One correction must be made in heading. Cross out "Forty" and substitute "1/4 Sec." The quarter section is to be designated by NE, SE, SW, or NW.

Snags are to be recorded by diameter classes under the heading "Dead Trees". Certain of these forms lack this column. On these forms record the snags in the D.B.H. column. Green trees are to be recorded by diameter and according to the designated tree classification.[1/] [2/] For diameters larger than provided for, write in diameter on blank lines at bottom of sheet.

Use the dot and bar system of recording trees. One dot equals one tree. One bar equals one tree. Place dots for the first four trees recorded in each diameter and tree class division to form a square. Next connect the four dots with four bars, enclosing the square. Dots and bars now represent eight trees. Lastly, place two more bars diagonally across the box connecting all four corners. The four dots and six bars used to complete the unit represent a total of ten trees (see completed tally sheet on page 38).

Summary of Cruising Data

(1) Summarize tree heights[3/] and plot height curve[4/] to determine the proper volume table[4/] for plot.

(2) Total data on "Tree Class Tally" forms by diameter and tree class.[1/] [2/] Snags are totaled separately and are not included in the green tree total.

(3) Summarize tree class tally data on "Summary of Tree Class Tally" form (see sample on page 39). One of these forms is used for each quarter section, two per plot. All green tree data on the "Tree Class Tally" are transferred to identical positions on the "Summary of Tree Class Tally" form. Figures are used to denote the number of trees represented by the dots and bars, using a red or blue pencil. Place figures in upper portion of each square. Enter snags by diameter class in unmarked column in front of "Total". Label this column, "Snags".

1/ Keen tree classification, p. 44.
2/ California risk classification, p. 55.
3/ Recording and summarizing tree height measurements, pp. 22-3.
4/ Height curve construction and volume determination, p. 23.

(4) Determine volumes of green trees from proper volume table for plot.[1] Care must be taken to use the mature volume table for class 3 and 4 trees and the immature table for class 1 and 2 trees.[2] Total the volumes for the trees in each square and enter in lower portion of square. No volumes are entered for snags. Scribner Decimal "C" method is used in recording and computing all volumes.

(5) Total the number of snags. Total both number of trees and volume of the green stand by diameter classes and by tree classes.[2] [3] The sums of the green stand totals, both trees and volume, are placed in the lower right hand corner of each sheet. Care must be exercised not to include the snags with the green stand.

Clip "Tree Class Tally" sheets crosswise to upper portion of "Summary of Tree Class Tally" forms. Fold lower half over "Tree Class Tally". Place in plot envelope.

"Tree Class Tally" and "Summary of Tree Class Tally" forms are summarized by the cruiser and estimator, or by the spotters.

Increment Cores

Select Class 2A or 3A trees[2] on well-drained sites from which to take cores. The wood of the increment core is to be four inches long. Cambium is to be left on core. The four-inch length will fit into a P. A. tobacco can, which makes an excellent container in which to collect in the field.

While holding core on the extractor, with indelible pencil clearly mark on each core: (a) D.B.H.; (b) tree class;[2] (c) if bug tree, serial number; (d) T. R. Sec.; (e) date taken.

Upon completion of the plot secure all cores for plot with rubber band, then lightly roll in 5 x 8 sheet of paper. Leave ends of roll open for ventilation to prevent moulding. On outside of paper write name of forest, plot, T. R. Sec., and date taken. Keep bundles of cores in well-ventilated container.

1/ Volume tables, p. 59.
2/ Keen tree classification, p. 44.
3/ California risk classification, p. 55.

Measuring Tree Heights with Topographic Abney Level

Measure one chain (66 feet) from center of tree. The topographic tape[1] can be used to advantage on sloping ground. With topographic abney level take two readings on tree, one at ground line, the other at top of tree (to topmost branches).

Three possible situations may be encountered in taking these readings.

(1) When observer's eye is on a level with the ground line. In this case the abney reads zero on ground line and a plus reading on the top height. The tree height is the abney reading on top height.

(2) When observer's eye is above the ground line. In this case the abney reading will be minus on the ground line and plus on the top height. Tree height is then the sum of both readings.

(3) When observer's eye is below ground line. In this case plus readings will be obtained on both ground level and top height. Tree height is the difference between these readings.

On tall trees readings should be taken at two chains' distance, as a better view may be obtained of the tree. At two chains the readings must be doubled for the correct height. Select only trees in vertical position, as leaners will give incorrect measurements.

Secure at least six height measurements of each diameter class represented on check plot, including trees of all degrees of age, vigor and dominance. The larger diameter classes should be well represented.

Recording Tree Height Measurements

Tree height measurements are to be recorded on "Tree Height Record" form (see sample form on page 40). One form is required on each 320-acre plot. The form has two divisions, one for each quarter section. In space provided at top of each division designate quarter section for which it is being used, i.e., NW, NE, SW, or SE.

Tree heights are to be recorded in actual feet. Enter measurements for each diameter class in first column of quarter section on which they were taken. The figures should be made small as at least three measurements are to be taken for each diameter class represented on the quarter section.

1/ Topographic abney level and topographic tape, p. 29.

Summary of Height Measurements

First average the height measurements of each diameter class for each quarter section placing these figures in the second column of each division, next find the average measurement of each diameter class for both quarters placing the final average in the last column, see completed form on page 40.

Height Curve Construction

On graph paper with 20 squares per inch plot average tree heights over diameter class. Carefully fit curve to points, see completed sample on page 41. Clip tree height form and plot curve together and file in plot envelope.

Site and Volume Table Determination

Compare height curve of plot with set of "Height Curves for Adjusted Volume Tables" on page 42. The curve in this set that the plot curve most closely approaches determines the plot site and the volume table to be used.

Volume Tables

The volume tables used on previous surveys were based on both diameter and height measurements. The estimating of tree heights proved such a prolific source of error it has been discontinued and only the diameters are now taken.

The volume tables now used represent the average volume per tree for each diameter on a given site. One set of these volume tables has been constructed for each site. The number of the set corresponds to that of the site. Thus Set No. 4 represents Site No. IV. Each set consists of five or six individual volume tables representing the volume per tree for approximately every five feet of increase in height of tree. These tables were numbered consecutively from best to poorest range within each site. Table sets Nos. 4 and 5 contain six volume tables apiece. Table set No. 3 contains 5 volume tables, see Volume Tables, page 59.

The tables are designated first by set number and then by table number. Thus 4-4 indicates set No. 4, table No. 4.

Separate sets of tables are to be used for the live and dead trees. The set for the dead trees is labeled, "Insect Killed Trees" and for the live trees, "Green Trees". The green tree sets are subdivided into "Mature" and "Immature" tables. The immature volumes are to be used for Keen Class 1 and 2 trees and mature volume for Keen Class 3 and 4 trees.1/

1/ Keen tree classification, p. 44.

On old plots for which site[1] and volume table number[1] were previously determined, the number of the volume table to be used will be found on the upper right hand corner of the "Guide to Plot" form[2] which is filed in plot envelope.[3]

VI. SURVEY EQUIPMENT AND ITS USE

Biltmore or Forest Cruiser Stick

Use of the Biltmore stick provides a quick and sufficiently accurate method of securing diameter measurements of both insect-killed and live trees on the regular survey work.

While sticks are manufactured for different lengths of reach--that is, the distance at which the stick should be held from the eye--a 25-inch-reach stick is suitable for most men and is furnished for use on the survey.

In taking measurements grasp the stick near the middle with thumb and fingers of right hand, thumb to be above, resting on Biltmore side of stick, fingers to be underneath on the Merritt hypsometer scale. Stand erect, face tree squarely, place beveled edge of stick squarely against tree at breast height (4 1/2 feet) and 25 inches from eye. Hold stick horizontal and at right angles to line of sight. Bring left end of stick to a point where line of sight intersects left side of tree. The diameter will be found at point on stick where line of sight intersects both stick and right side of tree. Use one eye only and do not move head while measuring.

The distance between eye and stick will be a prolific source of error unless care is exercised to insure its correctness. An excellent method to establish this distance is by using a piece of string with a loop large enough to slip up and down the stick readily. Tie a knot in the string at a distance of 25 inches from top or sharp edge of stick. Place knot between teeth and slide loop to that part of stick in contact with tree; extend arm as far as string will permit, which should be the correct distance of 25 inches. Use string for several days or until sure of distance. Measurements should be checked with diameter tape[4] at frequent intervals throughout season, especially on irregular-shaped trees.

1/ Site and volume table determination, p. 23.
2/ Guide to plot, p. 34.
3/ Preparation of plot envelope, p. 5.
4/ Diameter tape, p. 27.

As the diameters of trees increase toward the maximum it becomes increasingly difficult to obtain accurate measurements with a Biltmore stick. Therefore a diameter tape should be used to secure measurements of all trees 40 inches D.B.H. and over.

Trees forking over 4 1/2 feet above ground are considered as one tree. Trees forking under 4 1/2 feet are considered as two separate trees and measured accordingly.

Sources of Error in Using Biltmore Stick

The most common sources of error in using a Biltmore stick are listed in order of their importance.

(1) Incorrect distance between eye and stick.

(2) Turning head to read diameter.

(3) Not holding stick horizontally.

(4) Not holding stick at right angles to line of sight, resulting in one end of stick being nearer eye than other end.

(5) Stick held too high or too low.

Measurements for Construction of Biltmore Stick

Under certain conditions it may become necessary to construct a Biltmore stick. Sets of measurements for construction of sticks for various lengths of reach are shown in the following table.

MEASUREMENTS FOR CONSTRUCTION OF BILTMORE RULE

Diameter Breast High	Distance from eye to tree in inches				
	23	24	25	26	27
	Actual distance to be marked on stick in inches				
6 in.	5.29	5.31	5.34	5.36	5.38
8	6.82	6.85	6.90	6.93	6.96
10	8.26	8.31	8.36	8.41	8.46
12	9.67	9.69	9.76	9.83	9.89
14	10.92	11.01	11.09	11.17	11.25
16	12.13	12.26	12.36	12.46	12.56
18	13.34	13.47	13.59	13.70	13.81
20	14.46	14.61	14.75	14.89	15.02
22	15.55	15.72	15.89	16.05	16.19
24	16.60	16.79	16.95	17.11	17.30
26	17.62	17.82	17.99	18.20	18.38
28	18.59	18.82	19.04	19.24	19.44
30	19.55	19.79	20.02	20.24	20.46
32	20.47	20.72	20.97	21.21	21.45
34	21.36	21.64	21.91	22.16	22.42
36	22.23	22.52	22.81	23.08	23.33
38	23.07	23.38	23.69	23.99	24.27
40	23.91	24.24	24.56	24.86	25.16
42	24.71	25.05	25.38	25.71	26.03
44	25.50	25.87	26.23	26.55	26.89
46	26.26	26.65	27.01	27.36	27.72
48	27.01	27.41	27.80	28.17	28.54
50	27.76	28.18	28.57	28.96	29.34
52	28.48	28.91	29.32	29.72	30.11
54	29.18	29.63	30.06	30.48	30.89
56	29.88	30.35	30.79	31.22	31.64
58	30.56	31.04	31.49	31.94	32.38
60	31.23	31.73	32.20	32.67	33.12

From "Notes on the Biltmore Stick" by Donald Bruce, Proceedings of the Society of American Foresters, Vol. IX, No. 1, Jan., 1914.

Diameter Tape

One side of tape is graduate in feet and tenths of feet. The other side is graduated in the diameter equivalents of circumferences in inches and tenths of inches.

When the hook at end of tape is caught in bark the diameter scale faces outward. Place tape in horizontal position around tree at breast height (4 1/2 feet). Read diameter at start of graduations (not at hook). Diameters are taken in two-inch classes on the even numbers on all trees over 9.6 inches in diameter.

Keep tape oiled and free of rust. Do not kink, as breakage is likely to occur.

Increment Borer

The 10-inch increment borer is furnished as standard equipment on the insect surveys.

Start borer into thick bark at a convenient height on tree. Take particular care to direct borer toward center of tree and to hold the bit in a horizontal position. Avoid flutes or the flat sides on tree.

Extreme care must be used to protect cutting edge of bit, as only a slight nick will render it worthless. Use care to avoid bending extractor. Clean bore of bit with kerosene or stove oil occasionally to remove any pitch which may accumulate and cause cores to stick. In damp weather keep oiled to prevent rust.

Compass

A staff compass, Forest Service Standard or Geologist's type, is used to obtain directional guidance on the plot work. With care, surprisingly good results may be achieved with these compasses. However, for satisfactory performance the compass must be in good condition—needle lively, sights in alignment, and hair taut. The ball and spindle joints on mounting must work smoothly.

For speed and convenience in setting up the compass, mount on, and securely fasten to "Jacob's staff" the spindle and ball joint portion of the mounting, screw spindle socket portion into base of compass, using sufficient force to prevent its working loose.

Immediately upon arrival at starting point, set staff firmly in ground, mount compass on staff, raise sights, level compass, release needle and allow to settle. Then bring north end of needle into perfect alignment with zero or 90 degree graduations on arc. As the compass needle may not be perfectly straight, always read north end of needle. Take sight, fixing clearly in mind a very definite object, and go to it. If at any time uncertainty exists as to sight, set up immediately and sight again. Do not attempt to sight across wide canyons, as the sight will invariably be lost while traversing the canyon. Rather take a sight to the bottom and another sight from there to the opposite side. Before removing compass from staff always lift needle from pivot. In order to protect the sighting hair, fold the sights so that the one containing the hair is on the bottom.

Declination

Declination found to be satisfactory on old plots is given on the Guide to Plot form, see page 34, and the Plot Description form, see page 35. However, a correction may be necessary, as individual compasses vary.

On new plots start with general declination for area and make necessary corrections as work progresses.

Correction Factors for Compass Alignment

Error in Chains	Corrections in Degrees and Minutes
0.50	0° 21'
1.00	0° 43'
1.50	1° 05'
2.00	1° 26'
2.50	1° 47'
3.00	2° 09'

Corrections apply to lines one mile in length, double corrections for lines one half mile in length.

If compass line falls to right of true line, the correction is to be added to declination setting, if to left subtract the correction.

Tally Register

The tally register or counter records from 1 to 999. It operates by depressing a plunger, recording one digit each time depressed. Most models are provided with two buttons on the back for resetting. The tally register is so constructed that it is most conveniently held in left hand. It is provided with a ring to slip over the middle finger.

In counting paces[1/] the plunger is depressed each time the left foot hits the ground. In a short time this operation becomes almost automatic.

An extra spring to operate the plunger should be carried at all times as they occasionally break without warning. A pocket knife may be used to remove the screws to insert the new spring.

Topographic Abney Level

The topographic abney level used on forest insect surveys is similar in construction to the percent and degree abneys, the basic difference being in the design of graduations on the arc. It is recognizable by the word "Topographic" at one end of the arc and "Rise in feet per chain" at the other end. This arc is so divided, that at a distance of one chain (66 feet), each graduation represents a difference of one foot in elevation. The use of the abney on the forest insect surveys is (1) to obtain chainage corrections on slopes and (2) to measure the height of trees to obtain site quality.

Topographic Trailer Tape

The 2 1/2 chain length topographic tape is used on forest insect surveys. The tape is graduated for 2 chains of its length into links (100 links equal one chain) and the additional 1/2 chain length is graduated to correspond to slope readings with topographic abney so that for any abney reading up to 50, the horizontal distance of two chains may be obtained by holding the rear of the tape at the corresponding abney reading.

For example, if the abney reading is "40", the rear chain man will permit the tape to be drawn out past the two chain marker until the graduation "40" is reached. When held at this point and the tape is drawn tight along the line of slope, the correction for slope is automatically made, and the front end of the tape is two chains distant horizontally. Similar graduations occur on the reverse side of the tape at the one chain marker and allow for corrections to readings as high as 80 on the abney.

Use at least 15 pounds pull on tape. When going down slopes hold trailer to prevent tape from running and piling up at bottom. Never allow a tape to remain wet over night. Dry and oil as soon as possible. Keep repair kit on the job.

1/ Pacing, p. 13.

Equipment for Spotting and Random 1/4-Acre Circular Plot Cruising

The following is a list of equipment used by each crew member.

Compassman:

1 map of forest showing location of plot
1 staff compass and staff
1 tally register
1 5 x 8 tatum holder
2 or more section plats
2 5H pencils, eraser, sandpaper for pointing pencils

The following additional equipment is necessary for random 1/4-acre circular plot cruising:

1 abney level
1 diameter tape
1 form, Tree Heights on Permanent Sample Plots

Spotters:

1 5 x 8 tatum holder
3 or more spotting records
2 pieces lumber crayon--blue or black
1 4H pencil and eraser
1 2 1/2 lb. boy's axe
1 axe stone
1 Biltmore stick
1 diameter tape

Additional equipment necessary for random 1/4-acre circular plot cruise:

1 10-inch increment borer and receptacle for cores--usually a Prince Albert tobacco can.
2 forms - Tree Class Tally
1 indelible pencil

Equipment for Cruising by Strip Method

The following is a list of equipment used by each crew member:

Compassman

1 compass and staff
1 tally register
1 abney level
1 diameter tape
1 2 1/2-chain tape
1 tape repair kit
1 5 x 8 tatum holder
1 or more forms, Tree Heights on Permanent Sample Plots
1 3H pencil, stub, and eraser

Cruiser

1 Biltmore stick
1 diameter tape

Estimator

1 5 x 8 tatum holder
2 or more Tree Class Tally forms
1 3H pencil, stub, and eraser

Working Equipment

1 staff compass with mounting and case
1 box compass
1 Jacob staff
1 abney level
2 tally registers
2 Biltmore sticks
3 diameter tapes
1 2 1/2-chain topographic tape
1 tape repair kit
3 5 x 8 tatum holders
2 10-inch increment borers
2 tree class calculators
3 1-quart belt canteens
1 2-gallon canteen
3 spotting axes
1 office box
1 truck, tools, and chains
Credit cards and truck record book

Camping Equipment

2 tents, 8 x 10 or 10 x 12
1 folding table
2 folding benches
3 canvas cots
3 mattresses
1 Lang camp stove and pipe
1 6-man cooking outfit and box
2 grub boxes
1 gas lantern and box, also 1 dozen mantels, 1 generator
1 1-gallon gas can
1 No. 0 Baldwin Eagle shovel
1 3 1/2 lb. D.B. axe
1 10-inch file
1 axe stone
1 medical kit

Office Equipment

1 set survey instructions
1 set of maps of forests showing location of plots
1 survey manual
1 Insect Enemies of Western Forests
Plot envelopes with plot instruction

Forms

60 section plats
160 spotting records
20 tree height
6 plot and physical description
12 tree class tally
6 summary of tree class tally
12 sheets graph paper
24 time slips

Writing Supplies

3 5H pencils
6 3H pencils
3 indelible pencils
6 keel
1 penholder and half dozen assorted points
9 wedge erasers for pencil tips
6 pencil clips
1 small bottle ink
2 blotters
1 package paper clips

VII. FORMS USED ON SURVEY

	Page
Guide to Plot	34
Plot and Physical Descriptions	35
Section Plat	36
Spotting Record	37
Tree Class Tally	38
Summary of Tree Class Tally	39
Tree Height Record	40
Height Curve	41
Standard Height Curves	42

GUIDE TO PLOT

Forest: FREMONT Area: SILVER LAKE Unit: Embody

Plot: Rock Butte T: 28S R: 12E Sec.: 18S/2 Site: 4
Table: 4-4

Drainage: Bear Creek Nearest P.O.: Silver Lake County: Lake, Oregon

Date est.: Oct. 1939 Compass Declination: N 21° E Local attraction: None

INSTRUCTIONS FOR REACHING PLOT

Directions: From Silver Lake go north on Fremont Highway to Bear Flat road (2 mi.); go west on Bear Flat road to Seller's Marsh road (16.5 mi.); turn right on Seller's Marsh road and go to Antelop Mtn. road (0.6 mi.); turn right on Antelope Mtn. road and go to unmarked road (1.2 mi.); turn left on unmarked road and continu 0.5 mi. to F. S. section line marker on 30" pine on right side of road. S.W. corner of plot is 2 tallies west.

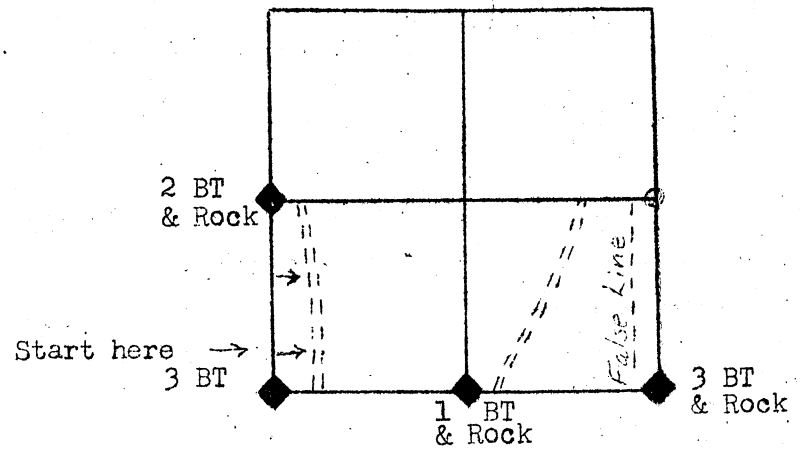
Dist. Ranger: Rogers

Camping place: Silver Lake R. S.

Springs: None

Accommodations: P.O., Store, Hotel, Restaurant at Silver Lake

(reverse side)



False line about 10 ch. from East End

PLOT DESCRIPTION - REGIONAL FOREST INSECT SURVEY

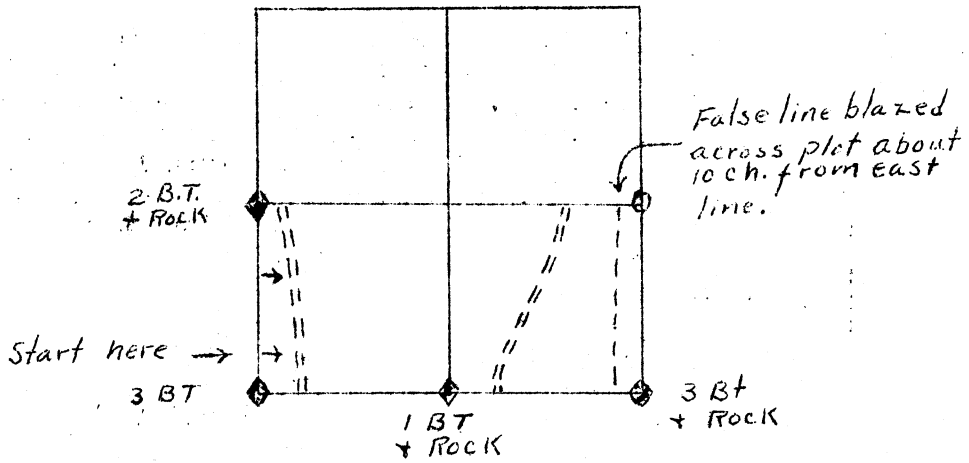
FOREST Fremont AREA Silver Lake UNIT Embody

NAME OF PLOT Rock Butte T. 28S R. 12 E Sec. 18 S½ M. W. Plot No.

Drainage Bear Creek Nearest P.O. Silver Lake County Lake State Ore

Date established 8-14-41 Years cruised 1 Date 9-13-42

Corners (West) SKETCH Corners (East)



(Indicate starting point and direction of cruise by arrows)

COMPASS: Declination 21° Local attraction None

INSTRUCTIONS FOR REACHING PLOT

(Give road directions, names of local rangers or others familiar with location, location of good camping place, location of springs, best available hotel or restaurant accommodations, etc.)

From Silver Lake go north on Fremont Highway to Bear Flat road (2 mi). Go west on Bear Flat road to Sellers Marsh road (16.5 mi), turn right on Sellers Marsh road and go to Antelope Mtn. road (0.6 mi. turn right on Antelope Mtn. road and go to unmarked road (1.2 mi.), turn left on unmarked road and continue 0.5 mi. to F.S. Section line marker on 30" pine on right side of road. S. W. Corner of Plot is 2 Rallies West.

District Ranger: J. Rogers at Silver Lake.

Camp at Silver Lake Ranger Station.

No Springs on Plot.

P.O. Store, Hotel, Restaurant at Silver Lake.

PHYSICAL DESCRIPTION

ACREAGE: Timbered 280 Cut 0 Burned 0 Open 40 Total 320

TOPOGRAPHY: Elevation 5000' General Features Rolling

SOIL: Origin Volcanic General Character Pumice and rock outcroppings

PLANT INDICATORS

FOREST ASSOCIATIONS: (Check one only)

Pine-juniper	Pine-lodgepole	Pine-Douglas fir
Pine-oak	Pine-sugar pine	Pine-larch
Pure pine ✓	Pine - white fir	

TREES: (Indicate percent ground covered by each species)

Abies (White fir) 1%	Pinus (Sugar pine)
Juniperus (Juniper)	Pinus (White pine)
Larix (Larch)	Pseudotsuga (Douglas fir)
Libocedrus (Incense cedar)	Quercus (Oak)
Picea (Engelmann spruce)	Thuja (Western red cedar)
Pinus (Lodgepole pine)	Tsuga (Western hemlock)
Pinus (Ponderosa pine) 99%	

SHRUBS: (Check all noted on plot)

Amelanchier (Service berry)	Prunus (Choke cherry)
Arctostaphylos (Manzanita) ✓	Prunus (Wild plum)
Artemesia (Sagebrush)	Purshia (Bitter brush) ✓
Castonopsis (Chinquapin)	Rhamnus (Cascara)
Ceanothus (Snow brush)	Rhus (Poison oak)
Ceanothus (Squaw carpet)	Ribes (Gooseberry)
Cercocarpus (Mountain mahogany) ✓	Ribes (Currant)
Corylus (Hazel)	Rosa (Wild rose)
Holodiscus (Cream bush)	Rubus (Thimbleberry)
Lonicera (Honeysuckle)	Sambucus (Elderberry)
Prunus (Bitter cherry)	Symphorocarpus (Snow berry)

FOREST CONDITIONS: Forest Type 20.5 Site Class 4

Reproduction P. Pine Density 37%

Ground cover Manzanita Density 60%

Fire injury None Last fire 1870

Remarks: (Note cuttings, windfalls, fires, or other abnormal conditions that might affect interpretation of plot data)

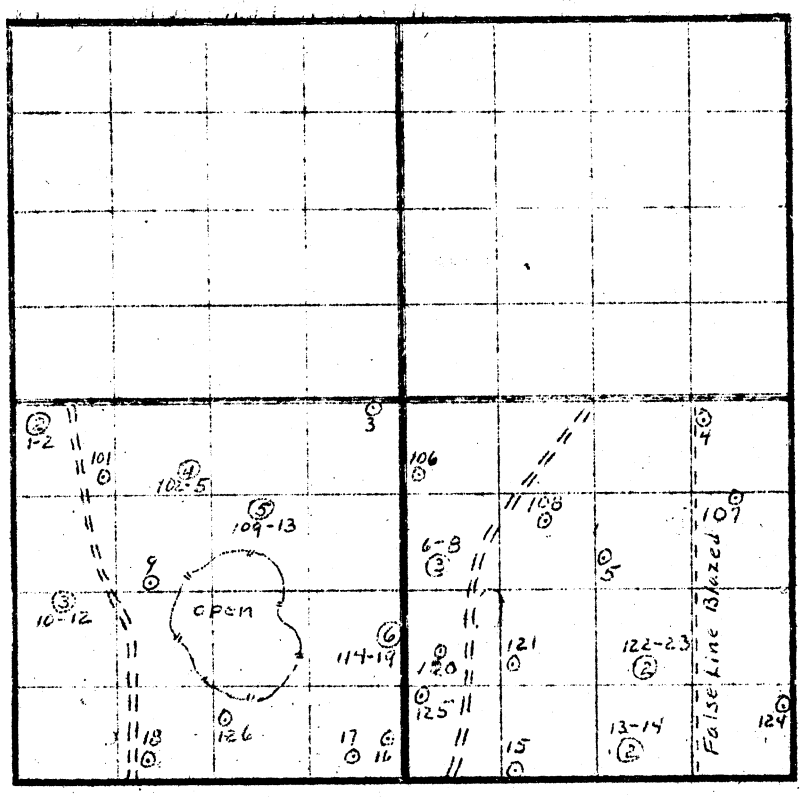
Beetle control in fall of 1940.

Forest: Fremont SECTION PLAT Plat: Rock Butte

Project area Silver Lake Unit Embody

Date 9-13-42 T. 28 S R. 12 E Sec. 18 S½

Compassman L. Seymour ¼ Sec.



Timbered acreage

Percentage by species

Volume B. F. per acre

Character of timber stand

Topography

General slope and exposure

Remarks: 1942 LOSS: Trees 44 Volume 33,000

Form EQ-37

SPOTTING RECORD

Forest: Fremont

Project area Silver Lake Unit Embody ~~Camp no.~~ Plot. Rock Butte

Date 9-13-42 Spotter Grant T. 28 S R. 12 E Sec. 18 S1/2

Tree No. 1942	Killed by	DBH	Logs	Volume			Tree Class	Remarks
1	DB	28		105			3-c	
2	DB	36		203			4-b	Fire scar
3	FH	20		36			3-c	
4	FH	44		323			4-b	
5	DM	28		105			3-c	
6	DB	34		176			4-c	
7	DB	16		17			4-d	
8	DB	10		2			4-d	
9	U.	26		83			3-c	
10	DB	10		2			3-d	
11	DB	38		232			3-b	Lightning struck
12	DB	32		152			3-c	
13	DB	48		390			4-c	
14	DB	28		105			4-c	
15	DV	34		176			4-d	
16	DM	28		105			3-c	
17	IO	14		11			1-b	Snow break
18	DM	20		36			2-c	
18 Totals				2259				

Form EQ-38

TREE CLASS TALLY

Forest Fremont Area Silver Lake Unit Embody

Plot Rock Battle Site 4 T. 285 R. 12 E Sec. 18 1/4 Sec. S.W.

Cruiser Grant Date 8-13-42 Cruise 10 percent Acres 160

DBH Snags	1 A	1 B	1 C	1 D	2 A	2 B	2 C	2 D	3 A	3 B	3 C	3 D	4 A	4 B	4 C	4 D	Total
10																	33
12																	51
14																	46
16																	33
18																	34
20																	35
22																	32
24																	32
26																	20
28																	16
30																	17
32																	24
34																	10
36																	10
38																	8
40																	1
42																	3
44																	
46																	1
48																	
50																	
16																	
	57	38	20	2	21	40	34	18	17	34	29	15	17	37	22	8	409

SUMMARY OF TREE CLASS TALLY

Forest *Fremont* Area *Silver Lake* Unit *Embody* Plot *Rock Butte*

Site *4-4* Acres *320* Cruise% *10* T. *28* S R. *22 E* Sec. *18* Subdiv. *S.W. ¼*

Cruisers *Grant, Austin, Seymour* Date *8-13-42*

DBH	1				2				3				4				Snags	Totals
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D		
10	6 12	9 18	11 22	1 2				6 12										33 66
12	12 60	16 80	7 35	1 5			5 25	7 35				3 36						51 276
14	10 120	8 88	1 11			1 11	13 143	4 44				9 108						46 525
16	11 187	2 34	1 17			5 85	7 119	1 17			1 18	2 36				3 54		33 567
18	6 150	2 50			1 25	13 325	5 125			1 27	5 135	1 27						34 864
20	8 288	1 36			7 252	10 360	2 72			2 76	7 266					1 38	2	38 1388
22	3 144				2 96	9 432	1 48		1 52	8 416	4 208			1 52	1 52	2 104		32 1604
24	1 64				6 384	2 128	1 64			8 544	8 544			2 136	3 204	2 136	1	32 2204
26					4 320				3 258	4 344				4 344	4 344		2	20 1610
28					1 100				4 440	5 550	1 110			2 220	3 330		3	16 1750
30									4 540	3 405	3 405			4 540	3 405			17 2295
32									3 486	3 486			5 820	11 1782	2 324		3	24 3898
34									2 380				1 190	4 756	3 570		2	10 1896
36													4 872	5 1090	1 218		2	10 2180
38													5 1250	1 250	2 500		1	8 2000
40														1 284				1 284
42													2 676	1 318				3 994
44																		
46														1 389				1 389
48																		
50																		
Total	57 1025	35 306	20 85	2 7	21 1177	40 1341	34 596	18 108	17 2156	34 2848	29 1636	15 207	17 3808	37 6161	22 2947	8 332		409 24790

Form EC-221

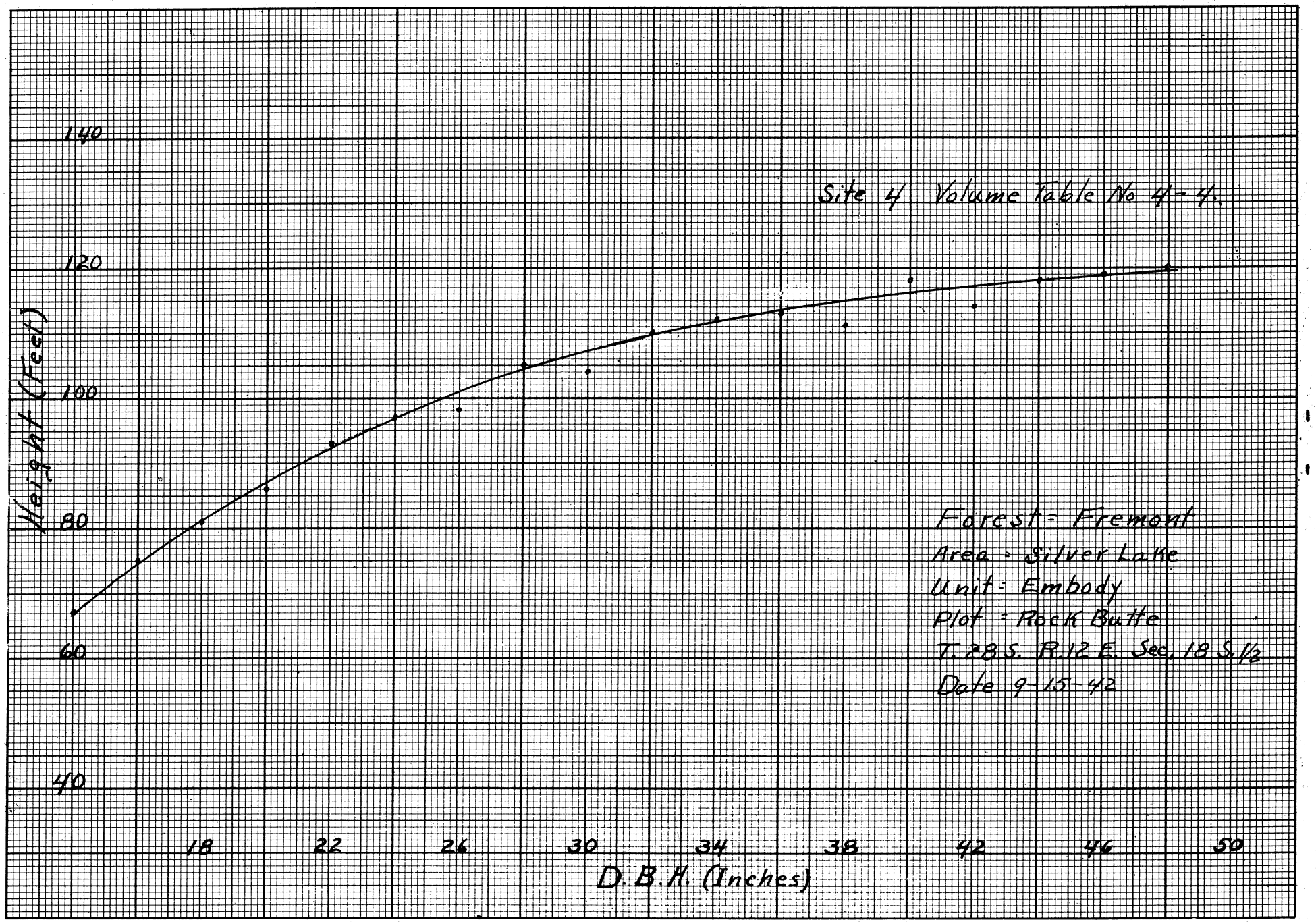
TREE HEIGHT RECORD

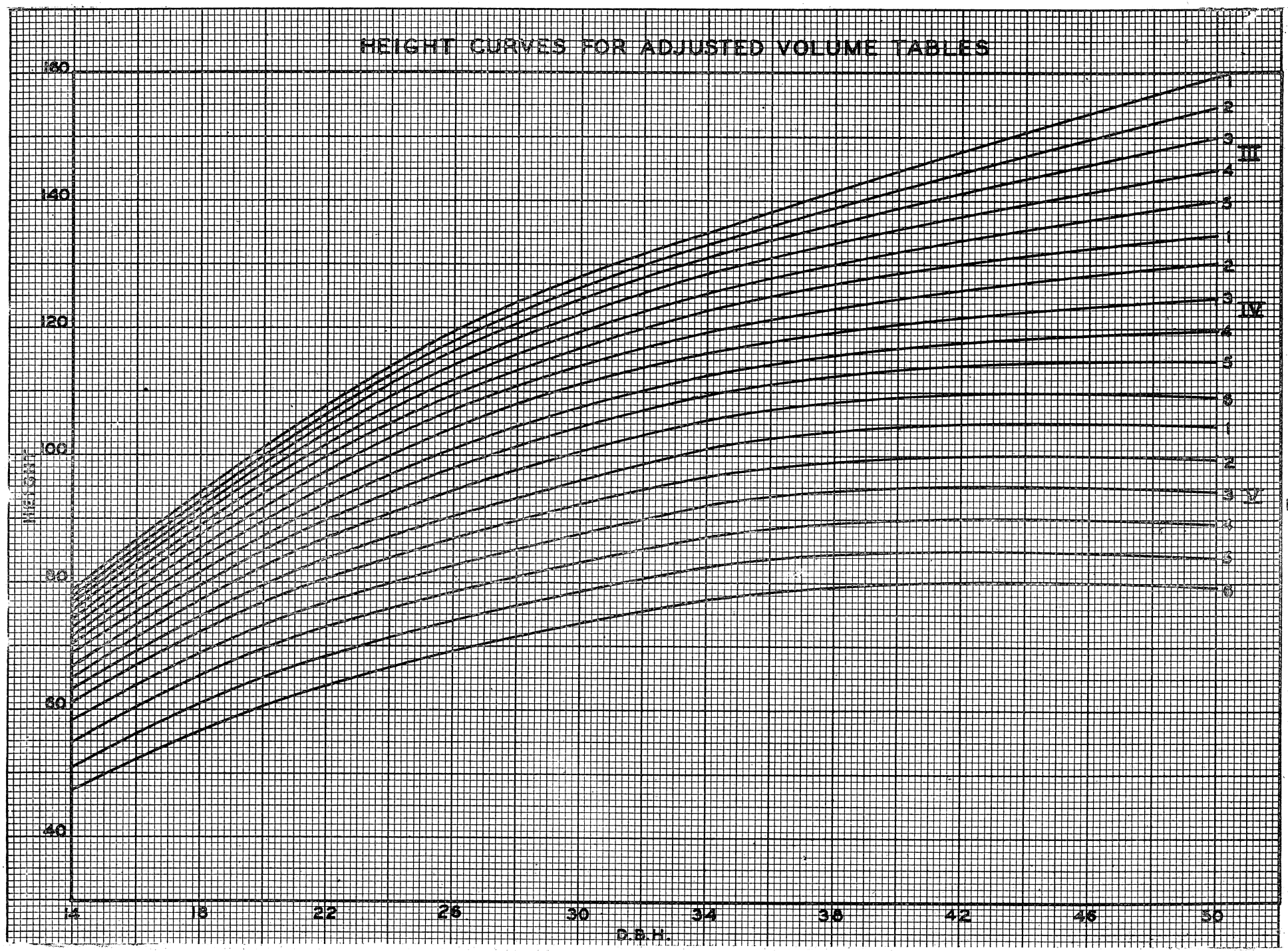
Forest Fremont Area Silver Lake Unit Embody

Plot Rock Butte T. 28 S R. 12 E. Sec. 18 S½

Cruiser O. B Austin Date 9-13-42

D.B.H.	¼ Sec. S.E. Individual Measurements	¼ Sec. S.E. Average	¼ Sec. S.W. Individual Measurements	¼ Sec. S.W. Average	Average for ½ Sec.
10	48 36 46 48	44	40 49 44	44	44
12	62 54 58	58	48 60 64 54	57	57
14	68 64 62 72 66	66	74 62 69	68	67
16	70 80 73	75	79 71 69 86	76	75
18	80 84 70 88 84	81	86 78 79	81	81
20	81 83 85 80	83	92 89 84 88	88	86
22	101 110 80 96	97	90 89 99 77	89	93
24	89 110 90 106	99	94 86 108 95	96	97
26	112 84 92 96	96	94 108 110 86	99	98
28	112 100 106 101	105	90 108 116	105	105
30	86 104 98 115	101	110 108 113 98	107	104
32	115 110 112	112	110 114 100	108	110
34	121 108 119 115	115	101 123 95 120	110	112
36	111 116 112	113	108 110 120	113	113
38	130 101 120 95	111	118 105 110 121 99	111	111
40	105 121 118 126	117	110 128 117 124	120	118
42	110 119 99 122	112	126 100 118	115	114
44	95 128 120	114	108 130 127	121	118
46	115 112 120	116	122 122	122	119
48	121	121	110 128	119	120
50					


Site 4 Volume Table No 4-4.
Height (Feet)
140
120
100
80
60
40
18
22
26
30
34
38
42
46
50
D. B. H. (Inches)
Forest = Fremont
Area = Silver Lake
Unit = Embody
Plot = Rock Butte
T. 28 S. R. 12 E. Sec. 18 SW¼
Date 9-15-42


HEIGHT CURVES FOR ADJUSTED VOLUME TABLES
160
140
120
100
80
60
40
HEIGHT
14
18
22
26
30
34
38
42
46
50
D.B.H.
III
IV
V
R

VIII. APPENDIX

Tree Classification

Two methods of rating the susceptibility of ponderosa pine to insect attack have been employed on past surveys. They are (1) "The Keen Tree Classification" and (2) "The California Risk Rating Classification". All green trees measured in making ten percent inventory cruises have been classified according to one or the other of these methods. The Keen system has also been applied to all insect killed trees marked on the plots, and to all green trees from which increment cores are taken. These methods of classification are described in (1) "Ponderosa Pine Tree Classes Redefined", see page 44, and (2) "Description of California Risk Rating Classification", page 55.

Keen Tree Class Calculator

Instructions for operation of the calculator, which is in sliderule form, are given on page 56.

Estimating Factor

Only a portion of the season's loss has been attacked by the time the survey is conducted. In order to determine the probable seasonal total, estimating factors developed from past surveys as to the percent of the total loss usually marked on any date may be employed. These factors (Grant's Curve) are given in the table on page 58.

Volume Tables

Volume tables arranged according to site are given for both green and insect-killed trees, see page 59.

UNITED STATES DEPARTMENT OF AGRICULTURE
Bureau of Entomology and Plant Quarantine
Division of Forest Insect Investigations

PONDEROSA PINE TREE CLASSES REDEFINED

By F. P. Keen
Senior Entomologist

The ponderosa pine tree classification developed by the writer[1] for determining susceptibility of ponderosa pines to bark beetle attack has been used in this region for timber-marking purposes and for insect mortality and growth studies during the past 6 years. It has also been adapted by Hornibrook[2] to fit conditions found in the Black Hills of South Dakota and Wyoming and by Thomson[3] for application in the Southwest. In practical field use the need has arisen for more exact definitions and a weighting of the more important factors, in order to obtain closer standardizing of interpretation and to iron out such ambiguities as existed in the original descriptions.

Following a recent study of 3,700 trees as to growth rates, crown characteristics, and susceptibility to bark beetle attack, new definitions have been prepared. Whereas no change has been made in the average criteria for any tree class, these new definitions should make possible an improvement in the classification of borderline trees so as to place them in the class most nearly representing their respective growth rate and mortality risk. The revised descriptions of the tree classes are as follows:

1/ Keen, F. P. 1936. Relative susceptibility of ponderosa pines to bark-beetle attack. Jour. Forestry 34: 919-927, illus. Oct.

2/ Hornibrook, E. M. 1939. A modified tree classification for use in growth studies and timber marking in Black Hills ponderosa pine. Jour. Forestry 37: 483-488, illus. June.

3/ Thomson, Walter G. 1940. A growth rate classification of southwestern ponderosa pine. Jour. Forestry 38: 547-553, illus. July.

REVISED DESCRIPTION OF TREE CLASSES

The two primary factors on which this tree classification is based are age and crown vigor. Each of these factors is subdivided into four parts, making a total of 16 tree classes. Although four age groups and four crown-vigor subdivisions can be recognized in any ponderosa pine stand, the tree characteristics which differentiate the age or vigor groups vary considerably in different parts of the pine region and on different sites, and hence cannot be described specifically, except for a particular site and for limited portions of the region. Thus the following descriptions apply primarily to average Site IV in central and southern Oregon and northeastern California. Hornibrook has given the corresponding descriptions for the Black Hills ponderosa pine, and Thomson has described the characteristics of similar age and vigor groups in the Southwest. Other modifications will be needed to fit conditions in other regions, but the general principles are the same anywhere.

AGE CLASSES

Trees are first divided into four age groups—young, immature, mature, and overmature. The purpose here is to recognize relative maturity or "physiological age" rather than any definite age limits as shown by the number of annual rings. Differences in site, moisture, elevation, and other environmental factors influence the age at which trees reach maturity in different parts of the ponderosa pine region. The tendency is for trees to reach maturity earlier on poor sites than on good sites.

The external characters most valuable as indicators of maturity are the color and character of the bark, the total height of the tree, shape of the top, character of branches and branching, and diameter. These characters for Site IV in the ponderosa pine stands of central and southern Oregon and northeastern California are given below in table 1.

Age Class 1.—Young trees. Commonly referred to as "bull pines" or "black jacks"; thrifty trees making rapid height and diameter growth; age usually less than 80 years.

D.b.h.—Rarely over 20 inches.

Height.—In lower crown canopy usually less than 60 percent of total mature height.

Bark.—Dark, grayish brown to black; rough, and deeply furrowed without plates, but with narrow ridges between the fissures (sometimes coloring at extreme base).

Branches.—Upturned and in whorls for upper three-fourths of crown; small for diameter of bole.

Top.—Usually pointed, with distinct whorls.

Age Class 2.--Immature trees; still making rapid height and diameter growth in thrifty trees; age approximately 80 to 180 years.

D.b.h.--Rarely over 30 inches.

Height.--Usually less than 90 percent of total height at maturity. Trees still under the general crown canopy.

Bark.--Dark reddish brown, with narrow, smooth plates between fissures on lower half of bole; dark, rough bark on upper half.

Branches.--Mostly upturned and in whorls for upper half of crown; horizontal near middle, horizontal or drooping below; small to medium size for diameter of bole.

Top.--Usually pointed, sometimes rounded, but with whorls indistinct.

Age Class 3.--Mature trees. Height growth practically complete; diameter growth slow; age approximately 180 to 300 years.

D.b.h.--Rarely over 40 inches.

Height.--Practically that of the general crown canopy; except intermediate, suppressed or top-killed trees.

Bark.--Light reddish brown with moderately large plates between the fissures on lower three-fourths of bole; dark bark showing in upper quarter.

Branches.--Upturned near top, middle crown horizontal, lower ones drooping; moderately large for size of bole.

Top.--Usually pyramidal or rounded, occasionally pointed; whorls indistinct except at extreme top.

Age Class 4.--Over-mature trees. Making no further height growth; diameter growth very slow; age more than 300 years.

D.b.h.--Wide latitude in diameters, but usually large in dominant trees.

Height.--Full height of general crown canopy, except suppressed, spike-topped or broken trees.

Bark.--Light yellow and uniform for entire bole, except in extreme top; plates usually very wide, long, and smooth; fissures often rather shallow.

Branches.--Large, heavy limbs, often gnarled or crooked; mostly drooping except in extreme top.

Top.--Usually flat; occasionally rounded or irregular.

The distinction between age classes 1 and 2 is based largely on color and roughness of bark as well as character of branching. While both are sometimes called "bull pines" or "black jacks", only class-1 trees have the rough, black bark for practically the entire length of the bole, and upturned branches in distinct whorls, so characteristic of young, juvenile growth. Class-2 trees have this dark, rough bark in the upper half of the bole, but the bark on the lower half is turning red and developing narrow plates on the ridges, particularly on the south side.

The distinction between age classes 2 and 3 is mainly a matter of height, character of the bark, and branching in the upper part of the tree. Class-2 trees are understory trees somewhat less than 90 percent of the height of the general crown canopy, whereas class-3 trees have practically reached the height of the general crown canopy and only show dark bark and upturned branches in the upper quarter of the crown.

The distinction between age classes 3 and 4 is more difficult to recognize, since there is no sharp line of demarcation between a mature and an overmature tree. Light colored bark for practically the entire bole, absence of dark bark on the bole except at the extreme top, and large heavy limbs, mostly horizontal or drooping, are the principal distinguishing features of overmaturity.

In the field, age classes of dominant and codominant trees are fairly distinctive. Suppressed and intermediate trees in the older-age classes often cause more difficulty, since their diameters are small and they frequently simulate the characters of younger trees. Since ponderosa pine usually grows in even-aged groups, the age class of the surrounding trees will usually give a clue to the age of suppressed individuals in the group.

CROWN-VIGOR CLASSES

It is a well-recognized silvicultural principle that the growth rate of trees for a given site and age class is directly proportional to the size of crown or area of leaf surface.4/ Therefore in this classification each age class is subdivided into four divisions based on size of crown and abundance of foliage. These subdivisions, grouping together trees of similar growth capacities, indicate four degrees of relative crown vigor and are designated A, B, C, and D from best to poorest.

4/ Dunning, Duncan. 1922. Relation of crown size and character to rate of growth and response to cutting in western yellow pine. Jour. Forestry 20: 379-389. Apr.

The tree class designation thus indicates maturity, growth capacity and beetle susceptibility over a relatively long period of time. The additional appraisal of current tree health may be used to indicate for individual trees their risk of bark beetle attack over the next few years. Both appraisals are needed in marking ponderosa pine on a selective basis, if future loss from beetles is to be avoided.

RELATIVE MORTALITY BY TREE CLASSES

Records of annual mortality in virgin ponderosa pine stands have been accumulated on a large series of sample plots in eastern Oregon, Washington, and northeastern California over a period of years. These records of standing tree losses, primarily from bark beetle attack but also including all agencies other than fire and windfall, constitute a preliminary basis for setting up actuarial mortality rates for each tree class. The record includes mortality data from three independent samples as follows:

Period	Years	Infestation condition	Acres cruised	Beetle-killed trees
1928-1931	4	Epidemic	15,000	27,465
1935-1937	3	Endemic	41,920	13,387
1939-1940	2	Endemic	55,489	10,557
Total	9		112,409	51,409

The structure of the living stand was based on several 10 per cent cruises of these sample plots in which 206,037 green trees were classified to obtain the average distribution of trees by classes for typical mature ponderosa pine stands of this region.

The mortality ratio in Table 3 is on a tree basis. It was obtained by dividing the average percentage of trees killed in a given class by the average loss for the stand as a whole. It thus gives a measure of relative susceptibility. For instance, loss in Class 3B averaged 0.8 percent, which was the average for the stand, hence the mortality ratio is 0.8/0.8 or 1.00. Class 4D trees are killed 3.8 times as often as the average for all trees, while Class 1A trees are taken only 1/10 as often.

TABLE 1.--AGE CLASSES

Character	Class 1	Class 2	Class 3	Class 4
Maturity:	Young	Immature	Mature	Overmature
Age:	Usually less than 80 years	Approximately 80 to 180 years	Approximately 180 to 300 years	More than 300 years
D.b.h.:	Rarely over 20 inches	Rarely over 30 inches	Rarely over 40 inches	Usually large diameters in dominant trees
Height:	In lower canopy usually less than 60% of total height of mature canopy	Height usually less than 90% of total height of mature canopy	Height practically that of general crown canopy (except of intermediate, suppressed or topkilled trees)	Full height of general canopy (except suppressed, spike-topped or broken trees)
Growth and taper:	Thrifty trees making rapid height and diameter growth. Rapid taper	Considerable height growth still in progress; good diameter growth in thrifty trees. Taper considerable	Height growth practically complete; diameter growth slow. Moderate taper	Making no height growth; diameter growth very slow. Least taper
Bark color:	Dark grayish brown to black (except at extreme base)	Dark reddish brown on lower half of bole; dark bark on upper half	Light reddish brown on lower three-fourths of bole; dark bark showing in upper one-fourth of bole	Light yellow; uniform color throughout bole (except at extreme top)
Bark plates:	No plates. Rough bark, deeply furrowed, with narrow ridges between fissures	Narrow smooth plates between fissures	Moderately large plates between fissures	Plates usually very wide, long, and smooth; fissures often rather shallow
Branches:	Branches upturned in upper three-fourths of crown; small for diameter of bole	Mostly upturned in upper half of crown; lower half horizontal or drooping; small to medium for diameter of bole	Upturned near top; middle horizontal; lower ones drooping; moderate for size of bole	Large, heavy limbs, often gnarled or crooked; mostly drooping, except in extreme top
Whorls:	Whorls distinct in upper crown	Whorls distinct in upper half of crown	Whorls indistinct except at extreme top of crown	Whorls indistinct and incomplete
Top:	Top usually pointed	Top usually pointed, sometimes rounded	Top usually pyramidal or rounded, sometimes pointed	Usually flat, occasionally rounded or irregular

Note: Description primarily applicable to central and southern Oregon and northern California, Site IV

In the study of growth rate of trees in relation to crown characteristics, the following factors, in order of their importance, were found to be the best outward indicators of crown vigor and inherent growth capacity:

(1) Size of crown--length, width, and circumference.
(2) Density of crown.
(3) Form of top--pointed, round, flat, or spiked.
(4) Location of crown on the bole.
(5) Position of tree--isolated, dominant, codominant, intermediate, or suppressed.

Apparently in uneven-aged stands, such as open-grown ponderosa pine, the size and density of a tree's crown usually reflects the tree's position as to dominance or light and the amount of root competition.

In defining the four crown-vigor classes, it is impossible to describe all the variations in crown shape which may be encountered. Crown size and density are the principal criteria, and typical trees of crown-class A, which might be considered as the ideal outline, may be used as a standard of comparison. In the following descriptions it should be understood that other shapes may still belong to that crown-vigor class, provided the total volume of crown comes within the established limits.

The crown-vigor classes are defined below, and their descriptions are given in condensed form in table 2.

A--Full vigor

Crown.--Full vigorous crowns with a length of 55 percent or more of the total height, and of average width or wider; with density average or better for its age class.

Foliage.--Needles of average length or longer, usually dense and thrifty.

Position.--Usually isolated or dominant; rarely codominant.

D.b.h.--Large for age.

B--Good to fair vigor

Crown.--Good to moderately vigorous crowns, with length from 30 to 55 percent of total height, if of average width and density; or a longer crown if narrow or somewhat thin; but neither sparse nor ragged.

Foliage.--Needles of average length, usually dense and thrifty.

Position.--Usually codominant, but sometimes isolated or dominant; rarely intermediate.

D.b.h.--Average or above for age.

C--Fair to poor vigor

Crown.--Fair to poor crowns, with length from 10 to 30 percent of total height if of average width and density, or long, sparse, and narrow; often flat on one or more sides.

Foliage.--Needles often short and thinly distributed, but of normal length and density when confined to top one-third of crown.

Position.--Usually intermediate, sometimes codominant or suppressed, but rarely isolated.

D.b.h.--Usually below average for age; sometimes large in decadent trees.

D--Very poor vigor

Crown.--Very short, less than 10 percent of the total height; sometimes merely a tuft at top of tree, or somewhat longer when sparse and ragged; usually very narrow or limbs all on one side.

Foliage.--Needles often short, and foliage sparse or scattered, or only tufts at end of twigs; but of normal length and density if reduced in quantity.

Position.--Usually suppressed or intermediate, but may occupy other positions if greatly reduced in vigor.

D.b.h.--Decidedly subnormal for age, but very old decadent trees may be of large diameter.

Current tree health

The present tree classification is primarily concerned with the relative maturity and inherent vigor or growth capacity of different classes of ponderosa pine. The factors, such as diameter, crown-size, position and general thrift, on which these classes are based, change but slowly over a period of years. In addition, there is the matter of current tree health which must be taken into consideration. For any tree, regardless of class, may become weakened or sick from such causes as deficiency of available moisture or food supply, root injuries, the debilitating effects of fire, insect attack, disease or other pathological conditions. The symptoms of poor health may be evidenced by decadence or dying of the top, shortening and thinning or poor color of the foliage, or the presence of dying twigs on portions of the crown. These symptoms of current tree health form the basis of Salman and Bongberg's[5] system of rating risk, and it is recognized that they may change rather rapidly from year to year.

5/ Salman, K. A. and J. W. Bongberg. 1942. Logging high-risk trees to control insects in the pine stands of Northeastern California. Jour. Forestry 40: 533-539.

TABLE 2.--CROWN-VIGOR CLASSES

Character	Class A	Class B	Class C	Class D
Crown vigor:	Full, vigorous.	Good to fair	Fair to poor	Very poor
Crown length:	Long, 55% or more of total height; or less only if more than average width	Average length, less than 55% of total height (approximately 30% to 55% if full and wide) or a longer crown if narrow or somewhat thin	Short (from 10% to 30% of height, if crown of normal density) or long, sparse, and narrow	Very short (less than 10% of total height) sometimes merely a tuft at top of tree, or somewhat longer when sparse and ragged
Crown width:	Usually average width or wider (narrower if very long and dense)	Usually average width or narrower; may be flat on one side	Usually narrow or flat on one or more sides	Usually very narrow and sparse, or limbs all or one side
Crown density:	Usually full and dense or of medium density if longer than 55%	Usually of full to medium density, not sparse or ragged	Often sparse and ragged except at very top	Sparse and ragged
Foliage:	Needles of average length or longer, usually dense and thrifty	Needles of average length, usually dense and thrifty	Needles often short and thinly distributed, but of normal length and density when confined to top one-third of crown	Needles often short; foliage sparse or scattered or only partially developed, but of normal length if reduced in quantity
Position:	Usually isolated or dominant, rarely codominant	Usually codominant; sometimes isolated or dominant; rarely intermediate	Usually intermediate; sometimes codominant or suppressed, but rarely isolated or dominant	Usually suppressed or intermediate, but may occupy other positions if greatly reduced in vigor
Diameter:	Large for age	Average or above for age	Usually below average for age; sometimes larger in decadent trees	Decidedly subnormal for age, but very old, decadent trees may be of large diameter

Note: The descriptions apply to the usual types of trees found in each class; where exceptions occur, the size of living crown and amount of foliage are the primary considerations in determining the vigor class.

TABLE 3.--General Stand Structure and Relative Mortality of Virgin Ponderosa Pine, by Tree Classes, in Eastern Oregon, Eastern Washington, and Northeastern California, for Trees 9.6 Inches and Over

Tree class	D.b.h.[1]	Volume[1]	Occurrence by[2]		Trees killed per year[3]	Mortality ratio (tree basis)
			Trees	Volume		
	Inches	Bd. ft.	Per cent	Per cent	Per cent	
1A	13.6	116	7.7	1.2	0.1	0.1
B	12.7	85	7.3	0.8	0.3	0.3
C	11.5	54	2.4	0.2	0.7	0.8
D	10.9	40	0.3	---	0.9	1.1
2A	21.4	509	5.2	3.6	0.2	0.2
B	19.2	362	11.7	5.8	0.5	0.6
C	15.5	185	6.7	1.7	0.8	1.0
D	12.4	76	1.8	0.2	1.3	1.5
3A	31.0	1,560	3.3	13.5	0.3	0.3
B	26.3	992	18.7	25.4	0.8	1.0
C	21.0	524	13.0	9.3	1.6	1.9
D	14.8	186	4.4	1.1	2.2	2.6
4A	38.4	2,635	3.2	11.5	0.3	0.4
B	34.2	1,990	6.7	18.2	1.2	1.4
C	29.2	1,340	3.7	6.8	2.3	2.7
D	20.1	525	0.9	0.7	3.2	3.8
	21.3	670	100	100	0.85	1.0

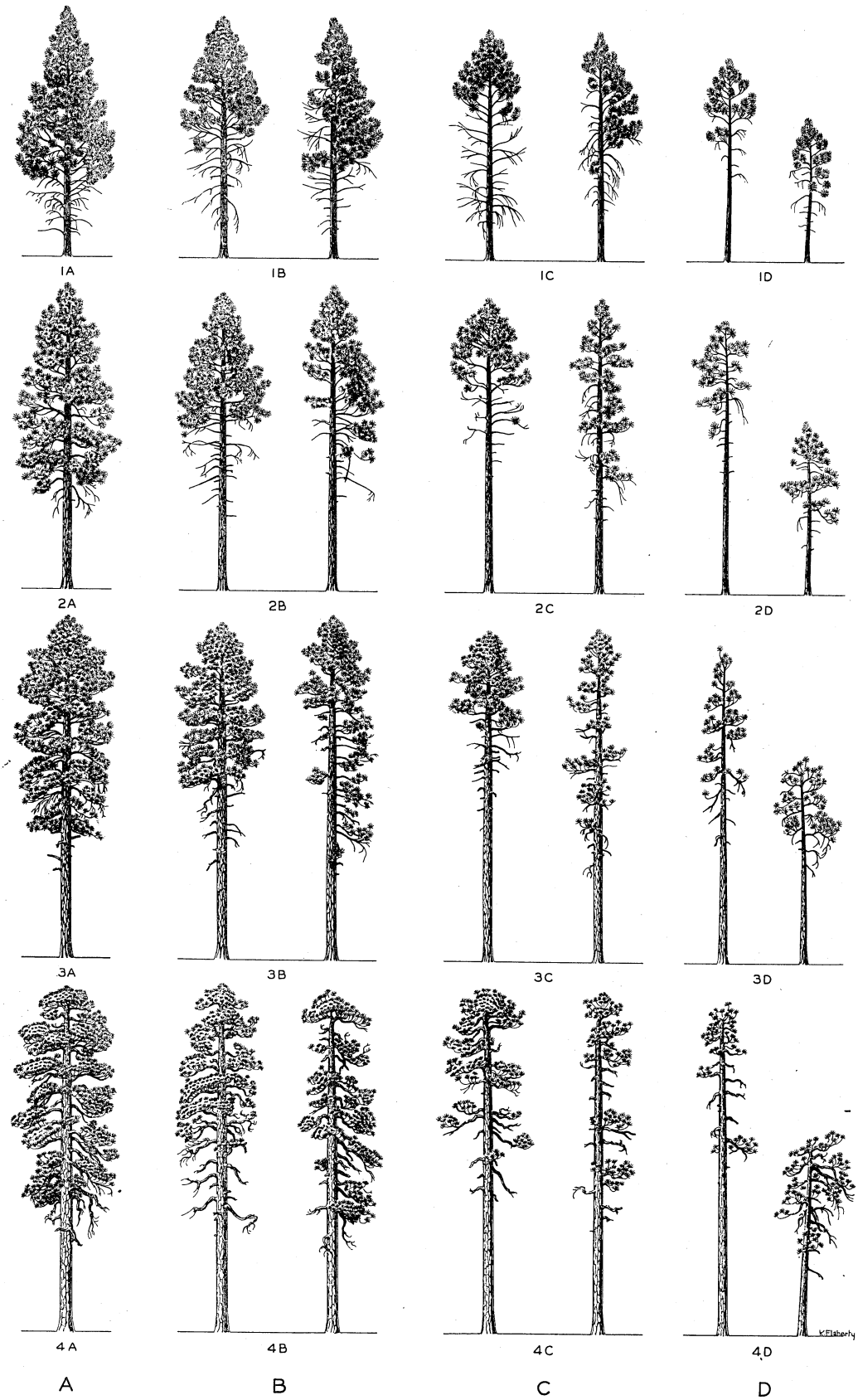
[1]From a 10-per cent cruise of 41,920 acres of sample plots in 1937.

[2]Based on 206,057 trees classified in 10-per cent cruises of 116,670 acres of sample plots in 1928-31, 1937, 1938, 1939.

[3]Based on 51,409 trees killed on 112,409 acres of sample plots during 1928-31, 1935-37, 1939-40.

A PONDEROSA PINE TREE CLASSIFICATION

BASED ON AGE AND VIGOR



PENALTY SYSTEM OF RATING RISK

For experimental purposes a system of rating tree health and risk to bark beetle attack by accumulating penalties for individual symptoms of unhealthy crown, needles, weakness and injury was devised by F. P. Keen in 1941 and first applied in the marking of trees for sanitation-salvage cutting on the Weyerhaeuser Timber Company's operation at Klamath Falls, Oregon.

Under this system, penalties corresponding to the estimated mortality ratios in excess of normal (1.00) for each symptom indicating poor tree health or weakness are applied on an empirical basis. Penalties for unhealthy crown and needle condition are appraised approximately as follows:

Condition	Penalty
Normal or better	0
Slight weakness	1
Moderate weakness	2
Bad weakness	3
Worst condition	4

An indication of the approximate penalty score for various common tree conditions are shown on the penalty score card on the next page. The total penalty score for a given tree is derived by adding penalties of 0 to 4 for unhealthy crown conditions, to penalties of 0 to 4 for poor needle conditions and 0 to 8 for various weaknesses and injury. Any tree regardless of tree class with no symptoms of poor health or weakness would rate 0 penalty, while the worst possible conditions would be a penalty of 16 ($4 \div 4 \div 8$). The relation of the penalty score to the California system of rating risk is also shown on the score card.

This system of determining relative tree health by a penalty score is still on an experimental and trial basis, and the penalties for different conditions may be changed as more information is obtained as to the importance of various symptoms as indicators of risk. Even so the general scheme of limiting the total score to 16 would be retained. So far this system has proved to be of value in the field in helping to appraise the proper risk rating of ponderosa pine. On sanitation-salvage operations in Oregon, trees with a penalty score of 5 or higher were marked for cutting.

PENALTY SCORES FOR SYMPTOMS OF POOR TREE HEALTH

	PENALTIES	
	Moderate Condition	Bad Condition
Crown Condition (Score 0-4)		
1. Weak spots in crown	0	1
2. Scraggly, scattered, irregular crown	1	2
3. Thin open crown throughout	1	3
4. Thin open crown, dense below	2	4
5. General poor vigor, unhealthy	2	4
Needle Condition (Score 0-4)		
1. Tufts at end of long bare branches	0	1
2. Length below average	0	1
3. Complement below average	1	2
4. Short needles in top, longer below	2	4
5. Fading or off color	2	4
Weakness or Injury (Score 0-8)		
1. Mistletoe or witches broom	0	1
2. Old spike, not active	0	1
3. Broken top, not dying below	0	1
4. Fire scar	0	1
5. Dying lateral twigs	1	2
6. Dying tip of terminal	2	4
7. Active top-killing	4	8
8. Active infestation	6	8

Relation of Penalties to California Risk Rating

Penalty		California Risk Rating
0	=	Risk 1
1 - 2	=	Risk 2
3 - 5	=	Risk 3
6 - over	=	Risk 4

DESCRIPTION OF CALIFORNIA RISK RATING CLASSIFICATION

In the following description a certain order is followed. The degree of vigor or susceptibility represented by the class first is stated. Next is a general statement of a broad impression of the crown condition of the class. Following this are statements describing symptoms connected with that degree of susceptibility or vigor each of which may be considered independently.

CLASS 1 — VIGOROUS — RESISTANT

Full foliage, healthy appearing crowns.
Foliage of healthy appearance, needles usually long or coarse, color good dark green.
Practically all twigs with normal foliage complement, no weakened portions of the crown.
No evidence of active infestations.

CLASS 2 — FAIR TO GOOD VIGOR — SOMEWHAT RESISTANT TO SLIGHTLY SUSCEPTIBLE

Fair to moderately vigorous crowns, imperfect in spots.
Foliage mostly healthy, needle length average or better, color fair to good.
Some twigs of branches lacking foliage complement, few small weakened portions of crown.
No evidence of active infestations.

CLASS 3 — FAIR TO POOR VIGOR — SLIGHTLY TO MODERATELY SUSCEPTIBLE

Crowns of fair to poor vigor, somewhat ragged or thin in parts.
Foliage in parts of crown thin, bunchy, or unhealthy, needles average to shorter than average, color fair to poor.
Some to many twigs lacking foliage, some branches fading or dead.
Evidences of active infestations concern only a very few scattered branches.

CLASS 4 — LACKING VIGOR — MODERATELY TO VERY SUSCEPTIBLE

Crowns of very poor vigor, ragged or thin, often showing evidences of active infestations.
Foliage thin or bunchy. Needles short, or sparse, or color poor.
Twigs of branches dead or dying. Large portions of crown weakened.

KEEN TREE CLASS CALCULATOR

To eliminate as far as possible the personal equation and to standardize interpretation of the various tree classes, a "tree class calculator" has been devised, which puts the essential factors of tree classification on a rule of thumb basis. The weight given to factors used in the construction of these rules was determined by a statistical analysis of the 3477 trees described on the 14 ten-acre plots. The methods of curvilinear multiple correlation described by Bruce and Reineke (8) were followed in making this analysis.

Crown Class Rule. Crown class as indicated by this slide rule is simply determined by the multiplication of relative length of crown, width of crown, and density of crown, as compared with the ideal outline of an "A" crown tree. The formulae might be written as follows:

Crown Class = L x W x D x S in which

L = Percent of crown length as compared with total height of tree. (In case of spike-top trees, the original total height of tree has to be assumed.)

W = Percent of width of crown as compared with the normal width of full-crowned "A" tree of similar height. (In trees of unsymmetrical crown, width is best taken as the radius of the widest side.)

D = Percent of density or fullness of crown as compared with normal fullness of an "A" tree. (This is best estimated by visualizing the crown pushed up the tree to fill the upper cone to normal density and then estimating what percent of total crown length would be filled.)

S = This is a correction factor (70 percent) for spike-topped or suppressed trees.

Operation of Rule:

(1) Pull slide until "W" is over "Length of crown %" determined
(2) Slip runner to "Width of crown %" determined
(3) Pull slide until "D" is under cross hair of runner if tree has normal top, or use "S" if the tree is suppressed or spike topped
(4) Read crown class on upper scale above the "density of crown %" determined as applicable.

Maturity Class Rule. This rule was first computed in the form of an alinement chart from a multiple curvilinear correlation analysis of the factors involved, and then converted to slide rule form. It was found that of the several factors tested, the percent of black bark and the diameter were the most important in determining relative maturity. Slight corrections were found to be needed for the various crown classes and for sites other than Site IV.

"Black bark %" is defined as the proportion of rough black bark characteristic of rapidly growing bark on a Class 1 tree, or that on the leader of older trees. In Class 1 trees this bark covers 100 percent of the bole. In older trees only a small percent of the top shows this growing condition. In older trees, where the limits of the black bark are not easily discernible, the point where the limbs are horizontal (drooping below and upturned above) can be used instead, for a satisfactory approximation.

Operation of the rule:

If on Site IV:

(1) Pull slide until crown class letter (previously determined) is over "black bark %"

(2) Read maturity class above appropriate D.b.h.

If Site III or Site V is involved; after step (1):

(2) Slip runner "Av."

(3) Push slide until appropriate site is under hair line of runner.

(4) Read maturity class above appropriate D.b.h.

ESTIMATING FACTORS
PERCENT OF TOTAL ANNUAL LOSS SPOTTED ON ANY DATE

Grant's Curve - 1941

	July (7)	Aug. (8)		Sept. (9)	Oct. (10)		Nov. (11)	Dec. (12)
Day	%	%	Day	%	%	Day	%	%
1	21	33.5	1	48.5	64.5	1	81.5	94.5
2	21.5	34	2	49	65	2	82	94.5
3	22	34.5	3	49.5	65.5	3	82.5	95
4	22.5	35	4	50	66	4	83	95
5	23	35.5	5	50.5	67	5	83.5	95.5
6	23.5	36	6	51	67.5	6	84	96
7	24	36	7	51.5	68	7	84.5	96.5
8	24	36.5	8	52	68.5	8	85	96.5
9	24.5	37	9	52.5	69	9	85.5	97
10	25	37.5	10	53	69.5	10	86	97
11	25	38	11	53.5	70	11	86.5	97.5
12	25.5	38.5	12	54	70.5	12	87	97.5
13	26	39	13	54.5	71	13	87.5	98
14	26	39.5	14	55	72	14	87.5	98.5
15	26.5	40	15	55.5	72.5	15	88	98.5
16	27	40.5	16	56	73	16	88.5	99
17	27.5	41	17	57	73.5	17	89	99
18	28	41.5	18	57.5	74	18	89.5	99.5
19	28	42	19	58	74.5	19	90	99.5
20	28.5	42.5	20	58.5	75	20	90	100
21	29	43	21	59	75.5	21	90.5	
22	29.5	43.5	22	59.5	76	22	91	
23	30	44	23	60	77	23	91.5	
24	30	44.5	24	60.5	77.5	24	92	
25	30.5	45	25	61	78	25	92	
26	31	45.5	26	61.5	78.5	26	92.5	
27	31.5	46	27	62	79	27	93	
28	32	46.5	28	62.5	79.5	28	93.5	
29	32.5	47	29	63	80	29	93.5	
30	32.5	47.5	30	64	80.5	30	94	
31	33	48	31		81	31		

GREEN STAND
Adjusted Volume Table - Scribner Decimal C
Site III

Mature						Immature				
Table Number						Table Number				
5	4	3	2	1	D.B.H.	5	4	3	2	1
Board feet in tens						Board feet in tens				
3	3	3	3	3	10	2	2	2	2	2
7	7	7	7	7	12	6	6	6	6	6
13	13	13	13	13	14	12	12	12	12	12
20	20	20	20	21	16	19	19	19	19	20
29	30	30	30	31	18	28	29	29	30	30
41	41	42	42	43	20	40	41	42	42	43
55	56	56	57	57	22	54	55	56	56	56
73	73	73	74	74	24	71	72	73	74	74
92	93	94	95	95	26	91	93	94	94	95
118	119	120	121	122	28	112	114	115	116	117
145	146	147	148	149	30	134	135	136	137	138
174	175	176	177	178	32					
205	207	208	209	210	34					
240	241	242	243	244	36					
277	279	280	281	282	38					
317	320	322	324	325	40					
355	362	368	373	378	42					
400	410	418	424	429	44					
449	460	467	473	477	46					
497	510	520	527	533	48					
542	560	577	592	607	50					
601	621	634	646	657	52					
651	674	698	720	739	54					
710	735	759	781	801	56					
770	800	829	858	886	58					
830	865	900	935	968	60					

GREEN STAND
Adjusted Volume Table - Scribner Decimal C
Site IV

Mature							Immature					
Table Number							Table Number					
6	5	4	3	2	1		6	5	4	3	2	1
Board feet in tens						D.B.H.	Board feet in tens					
2	3	3	3	3	3	10	2	2	2	2	2	2
6	6	6	7	7	7	12	5	5	5	5	5	5
11	11	12	12	12	13	14	9	10	11	11	11	12
17	18	18	19	19	20	16	15	16	17	18	18	19
26	27	27	28	28	29	18	23	24	25	26	27	28
36	37	38	40	40	41	20	33	34	36	38	38	40
49	51	52	53	54	55	22	44	46	48	50	52	53
65	66	68	69	71	72	24	58	61	64	66	68	70
83	85	86	88	90	91	26	73	76	80	83	86	89
105	108	110	113	115	117	28	91	96	100	104	107	111
127	131	135	138	141	143	30	108	114	119	124	128	132
152	157	162	166	169	172	32						
176	183	190	195	199	203	34						
203	212	218	223	229	236	36						
232	242	250	259	266	272	38						
261	274	284	295	302	311	40						
291	305	318	328	339	348	42						
323	338	353	366	380	390	44						
355	370	389	403	420	434	46						
390	410	427	446	463	480	48						
422	445	466	485	508	524	50						
458	480	503	530	552	580	52						
492	520	547	572	601	628	54						
527	555	589	620	651	680	56						
565	600	632	668	705	735	58						
601	640	676	715	756	790	60						
		720	765	810		62						
		760	810	860		64						
		815	865	920		66						
		870	925	980		68						
		920	970	1020		70						

GREEN STAND
Adjusted Volume Table - Scribner Decimal C
Site V

Mature							Immature					
Table Number							Table Number					
6	5	4	3	2	1		6	5	4	3	2	1
Board feet in tens						D.B.H.	Board feet in tens					
1	2	2	2	2	2	10	1	1	1	1	1	1
3	3	4	5	5	5	12	2	3	4	4	4	4
6	6	7	8	9	10	14	5	6	7	7	8	9
9	10	12	14	15	16	16	8	10	12	13	14	15
14	17	19	21	23	24	18	14	16	18	20	21	22
22	25	28	31	33	35	20	21	23	25	27	29	31
31	35	39	42	45	47	22	30	33	36	38	40	42
41	46	51	55	59	62	24	39	43	46	49	52	55
53	59	65	71	75	80	26	49	53	57	61	65	69
67	74	81	87	93	99	28	61	66	71	76	81	86
83	93	100	108	116	122	30	74	80	86	92	97	103
101	112	121	130	137	144	32						
119	129	141	152	160	168	34						
137	148	163	174	184	193	36						
154	169	185	197	209	221	38						
172	189	207	222	235	249	40						
189	209	227	246	259	275	42						
208	230	250	270	286	304	44						
227	251	272	294	313	333	46						
248	272	296	320	340	364	48						
268	296	320	347	369	396	50						
288	317	345	372	397	427	52						
309	340	371	400	428	459	54						
330	363	397	427	460	490	56						
353	388	425	459	492	527	58						
374	411	451	487	523	560	60						

INSECT-KILLED TREES
Adjusted Volume Table - Scribner Decimal C
Site III

D.B.H.	Table Number 5	4	3	2	1	D.B.H.
	Board feet in tens					
10	3	3	3	3	3	10
12	7	7	7	7	7	12
14	13	13	13	13	13	14
16	20	20	20	20	20	16
18	29	29	30	30	30	18
20	41	41	41	42	42	20
22	55	55	56	56	57	22
24	72	73	73	73	74	24
26	91	92	93	94	95	26
28	117	118	119	120	121	28
30	143	145	146	147	148	30
32	172	174	175	176	177	32
34	203	205	207	208	209	34
36	236	240	241	242	243	36
38	272	277	279	280	281	38
40	311	317	320	322	324	40
42	348	355	362	368	373	42
44	390	400	410	418	424	44
46	434	449	460	467	473	46
48	480	497	510	520	527	48
50	524	542	560	577	592	50
52	580	601	621	634	646	52
54	628	651	674	698	720	54
56	680	710	735	759	781	56
58	735	770	800	829	858	58
60	790	830	865	900	935	60

INSECT-KILLED TREES
Adjusted Volume Table - Scribner Decimal C
Site IV

D.B.H.	Table Number 6	5	4	3	2	1	D.B.H.
	Board feet in tens						
10	2	2	2	3	3	3	10
12	5	5	6	6	6	7	12
14	9	10	11	11	12	12	14
16	15	16	17	18	18	19	16
18	23	24	26	27	27	28	18
20	33	35	36	37	38	40	20
22	45	47	49	51	52	53	22
24	59	62	65	66	68	69	24
26	75	80	83	85	86	88	26
28	93	99	105	108	110	113	28
30	116	122	127	131	135	138	30
32	137	144	152	157	162	166	32
34	160	168	176	183	190	195	34
36	184	193	203	212	218	223	36
38	209	221	232	242	250	259	38
40	235	249	261	274	284	295	40
42	259	275	291	305	318	328	42
44	286	304	323	338	353	366	44
46	313	333	355	370	389	403	46
48	340	364	390	410	427	446	48
50	369	396	422	445	466	485	50
52	397	427	458	480	503	530	52
54	428	459	492	520	547	572	54
56	460	490	527	555	589	620	56
58	492	527	565	600	632	668	58
60	523	560	601	640	676	715	60
62					720	765	62
64					760	810	64
66					815	865	66
68					870	925	68
70					920	970	70

INSECT-KILLED TREES
Adjusted Volume Table - Scribner Decimal C
Site V

D.B.H.	Table Number 6	5	4	3	2	1	D.B.H.
	Board feet in tens						
10	1	1	1	1	2	2	10
12	2	2	3	3	3	4	12
14	4	5	5	6	6	7	14
16	6	7	8	9	10	12	16
18	8	10	12	14	17	19	18
20	13	16	19	22	25	28	20
22	22	25	28	31	35	39	22
24	30	33	37	41	46	51	24
26	40	44	48	53	59	65	26
28	51	56	61	67	74	81	28
30	67	72	77	83	93	100	30
32	81	87	94	101	112	121	32
34	91	100	109	119	129	141	34
36	103	113	124	137	148	163	36
38	118	129	141	154	169	185	38
40	131	143	157	172	189	207	40
42	147	160	174	189	209	227	42
44	162	176	191	208	230	250	44
46	179	194	210	227	251	272	46
48	193	210	228	248	272	296	48
50	212	230	248	268	296	320	50
52	222	242	264	288	317	345	52
54	238	260	283	309	340	371	54
56	252	276	302	330	363	397	56
58	268	294	322	353	388	425	58
60	284	311	341	374	411	451	60